Table A-3.5-2

Cask Body Temperatures and Pressures - 3-Hours Post-Fire

Cask Layer	Maximum Centerline Temperature (°F)	Maximum Temperature (°F)	Maximum Average Temperature Over the Entire Surface (°F)	Maximum Average Temperature Over the Active Fuel Length (°F)
Inner Cavity Surface	407	656	464	437
Outer Shell	397	761	563	N/A
Barrel	249	283	270	N/A

Parameter, units	Value
Ambient Air Temperature, °F	130
Maximum Cask Cavity Heat Load, Btu/hr	40,000
Maximum Inner Cavity Pressure Due to Argon and Residual Water, psig	242
Maximum Pressure Rise From All the Fuel Rods Rupture, psi	53
Maximum Total Accident Pressure in the Cask Cavity, psig	295
Maximum Fuel Rod Cladding Temperature, °F	769

Table A-3.5-3

Cask Body Temperature and Pressures
Post-Accident Steady State

Parameter, units	Value
Ambient Air Temperature, °F	130
Maximum Cask Cavity Heat Load, Btu/hr	40,000
Maximum Centerline Barrel Surface Temperature, °F	215
Maximum Centerline Outer Shell Temperature, °F	319
Maximum Centerline Inner Cavity Surface Temperature, °F	327
Maximum Fuel Rod Cladding Temperature, °F	769
Maximum Inner Cavity Pressure Due to Argon and Residual Water, psig	242
Maximum Pressure Rise from All the Fuel Rods Rupture, psi	53
Maximum Total Accident Pressure in the Cask Cavity, psig	295

FIGURE WITHHELD UNDER 10 CFR 2.390

Figure A-3.5-1

HTAS1 Model of IF-300 During Accident Sequence

A-3.6 Appendix

A-3.6.1 References

[1] "Certificate of Compliance for Radioactive Materials Packages," Model No. IF-300, Certificate Number 9001, Revision 23, Package Identification No. USA/9001/B( )F, Dated May 1990.

[2] Consolidated Safety Analysis Report for IF-300 Shipping Cask, NEDO-10084-3, Volumes 1 & 2, General Electric Company, Docket No. 71-9001, May 1985.

[3] "HTAS1: A Two-Dimensional Heat Transfer Analysis of Fuel Casks," Instruction Manual, NUREG/CR-0200, Volume 1, Section H1, (ORNL/NUREG/CSD-2/V1/R3), December 1984.

[4] "HEATING6: A Multidimensional Heat Conduction Analysis With Finite-Difference Formulation," Instruction Manual, NUREG/CR-0200, Volume 2, Section F10, (ORNL/NUREG/CSD-2/V2), 1981.

[5] "SCALE-3: A Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluation," Oak Ridge National Laboratory, NUREG/CR-0200 (ORNL/NUREG/CSD-2) Volumes I, II, and III, December 1984.

[6] Table I-4.0, Appendix I, Section III, Division 1 1986 ASME Code.

[7] Rust, James H., "Nuclear Power Plant Engineering," Haralson Publishing Company, Buchanan, Georgia, 1979.

[8] Lienhard, John H., "A Heat Transfer Textbook," Second Edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1987.

[9] "Packaging and Transportation of Radioactive Material," Title 10 Code of Federal Regulations, Part 71 (10CFR71), USNRC, 5/31/88.

[10] "Scoping Design Analyses for Optimized Shipping Casks Containing 1, 2, 3, 5, 7, or 10 Year PWR Spent Fuel," Oak Ridge National Laboratory ORNL/CSD/TM-149, January 1983.

[11] "Spent Fuel Dry Storage Testing At E-MAD (March 1978 Through March 1982," Westinghouse Electric Corporation, PNL-4533, 1982.

[12] Carslaw, H.S., and J.C. Jaeger, "Conduction of Heat in Solids," Oxford: Clarendon Press, 1947.

[13] Bolz, R.E., and G.L. Tuve, "CRC Handbook of Tables for Applied Science," Second Edition, Chemical Rubber Co., 1973.

[14] "Physical Characteristics of GE BWR Fuel Assemblies," Oak Ridge National Laboratory, ORNL/TM-10902, 1989.

[15] "Extended Fuel Burnup Demonstration Program," Nuclear Assurance Corporation, Final Report, DOE/ET/34014-10, September, 1983.

A-3.6.2 <u>Reference Calculations</u>

[A] IF-300 Shipping Cask BWR Basket Cask Thermal Analysis, PNFSI Calculation No. 420-11.0400, Revision 1.

[B] IF-300 Shipping Cask BWR Basket Thermal Analysis, PNFSI Calculation No. 420-11.0401, Revision 1.

A-3.6.3 Input/Output Listings

1. HTAS1 Input and Output Files For Normal and Accident Cases

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IF-300 TRANSFER CASK HTAS1 MODEL RUN 10, 4 CASES, NEW K FOR URANIUM AND
EMISSIVITY

CAVITY  18.75 3 90.125 7  40000
INNER SHELL  0.5 2 1 2 1.25 2
SHIELDING  4 5 3 5 3.75 5
MATERIAL  0
DURANIUM
100.0 14.3 300.0 15.9 500.0 17.4 800.0 19.6 1200.0 22.5
200.0 1190.0
32.0 0.0275  662.0 0.035  1225.0 0.048
OUTER SHELL  1.5 2 1.5 2
EMISSIVITY  0.84 0.84 0.84 0.84 0.84
FINS  0 1
9.62982 0.5625 0.5625 1.5 0
NEUTRON SHIELD  6.16 5 60.75 77.5
DELETE  PREFIRE  0 0.6 0.83
WATER JACKET  0.125 1
EMISSIVITY  0.488 0.488 0.830 0.830 0.830
PREFIRE  130  0.363
FIRE
POSTFIRE  0 130 0.363 0 0 0 123
FINAL  130 0.363 0 0 0 123
%
```

IF-300 TRANSFER CASK ETAS1 MODEL RUN 10, 4 CASES, NEW K -- PREFIRE SS

STEADY STATE TEMPERATURE DISTRIBUTION AFTER 12 ITERATIONS. TIME = 0.0

GROSS GRID		1 I			2 I		3 I					4 I		5 I
FINE GRID		1	2	3	4	5	6	7	8	9	10	11	12	13
	DISTANCE	-6.25	6.25	12.50	18.75	19.00	19.25	20.05	20.85	21.65	22.45	23.25	24.00	24 75
1	0.0	0.0	158.76	158.78	158.52	158.45	158.38	158.14	157.84	157.49	157.07	156.58	156.08	155.62
2	0.75	0.0	160.58	160.60	160.33	160.27	160.19	159.93	159.62	159.24	158.79	158.25	157 68	157.17
3	1.50	0.0	162.39	162.43	162.20	162.13	162.05	161.78	161.45	161.07	160.60	160.00	159.23	158.65
4	2.25	0.0	163.44	163.48	163.31	163.24	163.16	162.89	162 57	162.19	161.75	161.28	160.60	160 02
5	3.00	0.0	164.48	164.54	164.47	164.40	164.33	164.06	163.74	163.36	162.96	162.53	161.88	161.29
6	3.75	0.0	165.53	165 60	165.67	165.61	165.54	165.28	164.96	164.58	164.18	163.77	163 13	162 52
7	4.50	0.0	166 57	166.66	166.93	166.88	166.82	166.58	166.24	165 84	165 43	165.01	164.35	163.72
8	5.25	0.0	167.61	167.71	168.23	168.20	168.20	167.97	167 57	167 13	166.68	166.24	165 56	164.91
9	5.88	0.0	169.10	169.23	170.15	169.93	169.71	169.24	168.73	168.22	167 73	167.27	166 56	165.88
10	6.50	0.0	170.60	170.73	172.19	171.73	171.28	170.55	169.90	169.31	168 78	168.29	167 55	166.85
11	19 38	0.0	0.0	0.0	191.30	190.71	190.14	189.13	188.21	187.36	186.59	185.88	184.81	183.80
12	32.25	0.0	0.0	0.0	198.69	198.11	197.53	196.50	195.53	194.60	193.72	192.89	191.58	190.32
13	45.13	0.0	0.0	0.0	202.73	202.14	201.57	200.54	199.55	198.61	197 71	196.85	195 50	194 19
14	58.00	0.0	0.0	0.0	205.09	204.50	203.92	202.89	201.91	200.96	200.05	199.18	197 80	196.47
15	70.88	0.0	0.0	0.0	206.42	205.84	205.26	204.23	203.24	202.29	201.38	200.50	199 12	197.78
16	83.75	0.0	0.0	0.0	207.09	206.51	205.93	204.90	203 91	202.96	202 05	201.17	199 78	198 43
17	96.63	0.0	0.0	0.0	207.27	206.68	206.11	205.08	204.09	203.14	202.22	201.34	199 95	198.60
18	109.50	0.0	0.0	0.0	206.99	206.41	205.83	204.80	203.81	202.86	201.95	201.07	199 68	198.33
19	122.37	0.0	0.0	0.0	206.20	205.61	205.03	204.00	203 01	202.07	201.15	200 28	198.89	197.55
20	135.25	0.0	0.0	0.0	204.67	204.09	203.51	202.48	201.49	200.55	199.64	198.77	197 40	196 07
21	148.12	0.0	0.0	0.0	202.02	201.44	200.86	199.83	198.85	197.91	197.01	196.15	194 80	193.49
22	161.00	0.0	0.0	0.0	197.54	196.95	196.37	195.35	194.38	193.45	192.57	191.74	190 44	189.19
23	173.87	0.0	0.0	0.0	189.49	188.90	188.33	187.32	186.38	185.52	184.73	183.99	182 88	181.83
24	186.75	0.0	169.24	169.46	171.04	170.58	170.14	169.40	168.76	168.18	167.65	167.17	166.45	165.77
25	187.25	0.0	168.04	168.26	169.37	169.13	168.89	168.39	167.86	167.33	166.83	166.37	165 66	165.01
26	187.75	0.0	166.84	167.05	167.79	167.73	167.70	167.40	166.96	166.48	166.01	165.56	164.87	164.23
27	188.35	0.0	166.01	166.21	166.72	166.66	166.59	166.30	165.91	165.47	165.02	164.58	163 90	163.28
28	188.95	0.0	165.17	165.36	165.69	165.62	165.55	165.25	164.89	164.47	164.03	163.59	162 91	162.30
29	189.55	0.0	164.34	164.51	164.70	164.63	164.55	164.26	163.90	163.49	163.05	162.59	161 90	161.30
30	190.15	0.0	163.50	163.66	163.75	163.68	163.60	163.31	162.96	162.55	162.08	161.57	160.85	160.25
31	190.75	0.0	162.65	162.81	162.84	162.77	162.69	162.40	162.05	161.64	161.15	160.52	159.72	159 13
32	191.50	0.0	160.82	160.96	160.92	160.85	160.78	160.50	160.17	159.77	159.30	158.74	158.15	157.62
33	192.25	0.0	158.99	159.11	159.06	158.99	158.92	158.66	158.35	157.98	157.54	157.03	156.52	156.04

IF-300 TRANSFER CASK ETAS1 MODEL RUN 10, 4 CASES, NEW K -- PREFIRE SS

STEADY STATE TEMPERATURE DISTRIBUTION AFTER 12 ITERATIONS. TIME = 0.0

GROSS GRID						6 I	7 I
FINE GRID		14	15	16	17	18	19
	DISTANCE	25.98	27.21	28.45	29.68	30.91	31 03
1	0.0	0.0	0.0	0.0	0.0	0.0	0 0
2	0.75	0.0	0.0	0.0	0.0	0.0	0 0
3	1.50	0.0	0.0	0.0	0.0	0.0	0 0
4	2.25	0.0	0.0	0.0	0.0	0.0	0 0
5	3.00	0.0	0.0	0.0	0.0	0.0	0 0
6	3.75	0.0	0.0	0.0	0.0	0.0	0 0
7	4.50	0.0	0.0	0.0	0.0	0.0	0 0
8	5.25	0.0	0.0	0.0	0.0	0.0	0 0
9	5.88	0.0	0.0	0.0	0.0	0.0	0 0
10	6.50	0.0	0.0	0.0	0.0	0.0	0 0
11	19.38	183.06	182.34	181.63	180.93	180.25	180 12
12	32.25	189.31	188.37	187.49	186.66	185.88	185 71
13	45.13	193.14	192.16	191.23	190.35	189.52	189 36
14	58.00	195.42	194.42	193.47	192.56	191.70	191 53
15	70.88	196.71	195.70	194.74	193.82	192.94	192 77
16	83.75	197.36	196.35	195.38	194.45	193.56	193 39
17	96 63	197.53	196.51	195.54	194.61	193.72	193.55
18	109.50	197.26	196.25	195.28	194.35	193.47	193 29
19	122.37	196.49	195.48	194.52	193.60	192.73	192.56
20	135.25	195.01	194.02	193.07	192.17	191.31	191.15
21	148.12	192.46	191.48	190.55	189.68	188.86	188.70
22	161.00	188.16	187.21	186.33	185.50	184.73	184.59
23	173 87	0.0	0.0	0.0	0.0	0.0	0.0
24	186.75	0.0	0.0	0.0	0.0	0.0	0.0
25	187.25	0.0	0.0	0.0	0.0	0.0	0.0
26	187.75	0.0	0.0	0.0	0.0	0.0	0.0
27	188.35	0.0	0.0	0.0	0.0	0.0	0.0
28	188.95	0.0	0.0	0.0	0.0	0.0	0.0
29	189.55	0.0	0.0	0.0	0.0	0.0	0.0
30	190.15	0.0	0.0	0.0	0.0	0.0	0.0
31	190.75	0.0	0.0	0.0	0.0	0.0	0.0
32	191.50	0.0	0.0	0.0	0.0	0.0	0.0
33	192.25	0.0	0.0	0.0	0.0	0.0	0.0

IF-300 TRANSFER CASE ETAS1 MODEL RUN 10, 4 CASES, NEW K -- FIRE TR

TRANSIENT TEMPERATURE DISTRIBUTION AFTER 218 TIME STEPS, TIME = 3.00000D+01

GROSS GRID		1 I			2 I		3 I					4 I		5 I
FINE GRID		1	2	3	4	5	6	7	8	9	10	11	12	13
	DISTANCE	-6.25	6.25	12.50	18.75	19.00	19.25	20.05	20.85	21.65	22.45	23.25	24.00	24.75
1	0.0	0.0	729.49	740.81	800.74	807.08	813.70	837.00	864.25	896.55	935.43	983.01	1037 02	1096.44
2	0.75	0.0	634.53	647.24	713.47	720.10	727.45	752.50	781.74	816.28	857.80	909.20	970.63	1037.46
3	1.50	0.0	551.67	566.55	640.60	647.77	655.25	681.31	711.26	745.85	786.35	835.72	910.40	984.54
4	2.25	0.0	513.98	530.09	608.29	615.51	623.03	649.11	678.76	712.32	749.87	790.25	863.25	941.01
5	3.00	0.0	480.97	497.95	579.35	586.47	593.87	619.41	648.23	680.45	715.75	752.98	825.09	905.36
6	3.75	0.0	452.85	470.34	554.17	561.06	568.19	592.69	620.31	651.22	685.09	721.14	793.29	875 67
7	4.50	0 0	429.86	447.44	533.17	539.76	546.54	569.30	595.34	624.93	657.82	693.46	766.23	850.47
8	5.25	0.0	412.17	429.40	516.80	523.31	529.95	549.35	573.27	601.46	633 56	669.10	742.74	828.65
9	5.88	0.0	394.60	411.12	501.87	509.10	517.49	534.67	556.77	583.76	615.26	650.78	725.19	812.35
10	6.50	0.0	389.70	405.98	501.40	503.46	508.11	521.65	541.67	567.45	598.36	633.90	709 04	797 35
11	19.38	0.0	0 0	0.0	435.09	435.54	438.02	447.06	462.26	483.24	509 63	541.06	607.92	686.34
12	32.25	0.0	0.0	0.0	339.95	340.02	341.43	346.92	356.19	369.04	385.26	404.63	446.66	497.37
13	45.13	0.0	0 0	0.0	335.77	335.82	337.12	342.41	351.53	364.29	380.53	400.06	442.39	493 18
14	58.00	0.0	0.0	0.0	337.71	337.75	339.05	344.32	353.42	366.18	382.41	401.94	444.25	494.98
15	70.88	0.0	0.0	0.0	339.01	339.05	340.35	345.62	354.71	367.46	383.68	403.20	445.47	496 16
16	83.75	0.0	0.0	0.0	339.66	339.71	341.00	346.27	355.37	368.11	384.32	403.83	446.08	496 76
17	96.63	0.0	0.0	0.0	339.84	339.88	341.18	346.44	355.54	368.28	384.49	403.99	446.25	496.91
18	109.50	0.0	0.0	0.0	339.56	339.61	340.90	346.17	355.27	368.01	384.22	403.73	445.99	496.67
19	122.37	0.0	0.0	0.0	338.80	338.84	340.14	345.41	354.50	367.25	383.47	402.99	445.27	495.97
20	135.25	0.0	0.0	0.0	337.68	337.73	339.03	344.32	353.42	366.17	382.39	401.90	444.18	494.90
21	148.12	0.0	0.0	0.0	343.23	343.31	344.70	350.18	359.44	372.26	388.45	407.78	449 73	500 34
22	161.00	0.0	0.0	0.0	440.01	440.45	442.90	451.86	466.97	487.87	514.19	545.56	612.27	690 44
23	173.87	0.0	0.0	0.0	493.88	494.51	497.49	508.18	526.02	550.55	581.29	617.75	695.08	784.90
24	186.75	0.0	457.57	469.90	535.02	536.22	540.09	552.36	571.07	595.48	624.94	658.84	731.28	817.53
25	187.25	0.0	461.02	473.48	538.24	543.54	550.07	564.85	585.16	610.64	640.73	674.78	746.74	831 93
26	187.75	0.0	473.59	486.42	551.52	556.66	561.83	578.36	600.23	626.84	657.63	691.90	763.42	847.48
27	188.35	0.0	486.32	499.36	564.82	570.38	576.14	595.92	619.75	647.77	679.55	714.26	785.41	868.00
28	188.95	0.0	502.98	516.00	581.48	587.48	593.73	615.52	641.00	670.44	703.47	739.03	810.12	891.11
29	189.55	0.0	523.46	536.23	601.16	607.49	614.09	637.18	663.97	694.82	729.52	766.75	838.31	917.51
30	190.15	0.0	547.63	559.94	623.58	630.09	636.89	660.73	688.46	720.63	757.56	798.35	871.05	948.11
31	190.75	0.0	575.34	586.96	648.48	655.03	661.88	685.95	714.12	747.23	786.63	835.74	909.91	983.92
32	191.50	0.0	653.50	663.56	719.48	725.83	732.48	756.00	783.87	817.28	858.01	909.00	970.17	1036.95
33	192.25	0.0	745.96	754.96	805.85	811.77	817.99	839.96	866.04	897.38	935.59	982.80	1036.61	1096.00

IF-300 TRANSFER CASE ETAS1 MODEL RUN 10, 4 CASES, NEW K -- FIRE TR

TRANSIENT TEMPERATURE DISTRIBUTION AFTER 218 TIME STEPS, TIME = 3.00000D+01

GROSS GRID						6 I	7 I
FINE GRID		14	15	16	17	18	19
	DISTANCE	25.98	27.21	28.45	29.68	30.91	31.03
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.75	0.0	0.0	0.0	0.0	0.0	0.0
3	1.50	0.0	0.0	0.0	0.0	0.0	0.0
4	2.25	0.0	0.0	0.0	0.0	0.0	0.0
5	3.00	0.0	0.0	0.0	0.0	0.0	0.0
6	3.75	0.0	0.0	0.0	0.0	0.0	0.0
7	4.50	0.0	0.0	0.0	0.0	0.0	0.0
8	5.25	0.0	0.0	0.0	0.0	0.0	0.0
9	5.88	0.0	0.0	0.0	0.0	0.0	0.0
10	6.50	0.0	0.0	0.0	0.0	0.0	0.0
11	19.38	1383.81	1463.53	1470.66	1455.41	1309.88	1314.54
12	32.25	677.50	843.58	997.28	1140.62	1275.54	1281.08
13	45.13	663.60	826.47	982.32	1131.69	1275.04	1280.60
14	58.00	664.76	827.13	982.67	1131.87	1275.15	1280.71
15	70.88	665.69	827.83	983.16	1132.15	1275.23	1280.78
16	83.75	666.16	828.19	983.40	1132.29	1275.27	1280.82
17	96.63	666.29	828.28	983.47	1132.33	1275.28	1280.83
18	109.50	666.09	828.14	983.37	1132.27	1275.26	1280.81
19	122.37	665.54	827.73	983.09	1132.11	1275.21	1280.77
20	135.25	664.98	827.51	983.05	1132.10	1275.15	1280.71
21	148.12	679.82	845.30	998.46	1141.29	1275.73	1281.27
22	161.00	1384.31	1463.59	1470.67	1455.45	1310.26	1314.91
23	173.87	0.0	0.0	0.0	0.0	0.0	0.0
24	186.75	0.0	0.0	0.0	0.0	0.0	0.0
25	187.25	0.0	0.0	0.0	0.0	0.0	0.0
26	187.75	0.0	0.0	0.0	0.0	0.0	0.0
27	188.35	0.0	0.0	0.0	0.0	0.0	0.0
28	188.95	0.0	0.0	0.0	0.0	0.0	0.0
29	189.55	0.0	0.0	0.0	0.0	0.0	0.0
30	190.15	0.0	0.0	0.0	0.0	0.0	0.0
31	190 75	0.0	0.0	0.0	0.0	0.0	0.0
32	191.50	0.0	0.0	0.0	0.0	0.0	0.0
33	192.25	0.0	0.0	0.0	0.0	0.0	0.0

IF-300 TRANSFER CASE ETAS1 MODEL RUN 10, 4 CASES, NEW K -- POSTFIRE TR

TRANSIENT TEMPERATURE DISTRIBUTION AFTER 147 TIME STEPS, TIME = 5.00000D+01

GROSS GRID		1 I			2 I		3 I					4 I		5 I
FINE GRID		1	2	3	4	5	6	7	8	9	10	11	12	13
	DISTANCE	-6.25	6.25	12.50	18.75	19.00	19.25	20.05	20.85	21.65	22.45	23.25	24.00	24.75
1	0.0	0.0	591.67	605.40	661.22	665.80	670.55	686.86	704.98	724.84	745.83	765.25	774.26	760.32
2	0.75	0.0	588.21	606.63	665.55	669.34	673.22	686.27	700.12	714.32	727.81	737.87	737.96	720.81
3	1.50	0.0	580.28	602.94	662.60	665.42	668.26	677.48	686.58	695.10	702.40	708.03	706.74	689.53
4	2.25	0.0	575.28	599.80	658.74	661.00	663.26	670.37	676.99	682.64	686.63	687.99	681.78	664.31
5	3.00	0.0	569.89	595.86	653.47	655.19	656.86	661.90	666.22	669.39	670.76	669.52	660.45	643.00
6	3.75	0.0	564.55	591.58	647.47	648.61	649.68	652.66	654.87	655.91	655.25	652.26	641.44	624.23
7	4.50	0.0	559.65	587.41	641.38	641.84	642.21	643.05	643.31	642.55	640.29	636.06	624.11	607.25
8	5.25	0.0	555.52	583.74	635.90	635.43	634.68	633.24	631.77	629.51	625.97	620.79	608.08	591.64
9	5.88	0.0	551.30	579.89	628.67	627.83	626.84	624.77	622.26	618.97	614.57	608.75	595.58	579.50
10	6.50	0.0	550.74	579.41	622.70	621.03	619.36	616.43	613.00	608.83	603.67	597.33	583.80	568.07
11	19.38	0.0	0.0	0.0	515.77	515.18	514.53	513.25	511.71	509.83	507.56	504.81	498.63	490.64
12	32.25	0.0	0.0	0.0	415.17	414.64	414.23	413.69	413.21	412.74	412.20	411.49	410.00	408.12
13	45.13	0.0	0.0	0.0	402.45	401.91	401.45	400.88	400.49	400.21	399.95	399.63	398.75	397.20
14	58.00	0.0	0.0	0.0	403.32	402.78	402.32	401.73	401.34	401.08	400.85	400.57	399.75	398.21
15	70.88	0.0	0.0	0.0	404.51	403.97	403.50	402.91	402.52	402.26	402.03	401.74	400.92	399.36
16	83.75	0.0	0.0	0.0	405.14	404.60	404.14	403.54	403.15	402.88	402.65	402.36	401.53	399.96
17	96.63	0.0	0.0	0.0	405.31	404.76	404.30	403.71	403.32	403.05	402.81	402.52	401.69	400.12
18	109.50	0.0	0.0	0.0	405.05	404.51	404.04	403.45	403.06	402.79	402.56	402.27	401.44	399.88
19	122.37	0.0	0.0	0.0	404.37	403.83	403.37	402.78	402.39	402.12	401.89	401.60	400.77	399.22
20	135.25	0.0	0.0	0.0	404.29	403.75	403.30	402.72	402.33	402.04	401.77	401.44	400.54	398.96
21	148.12	0.0	0.0	0.0	418.14	417.61	417.20	416.65	416.17	415.69	415.13	414.42	412.91	411.00
22	161.00	0.0	0.0	0.0	516.93	516.33	515.65	514.33	512.79	510.96	508.78	506.16	500.17	492.20
23	173.87	0.0	0.0	0.0	575.27	574.63	573.80	571.92	569.34	566.03	561.93	556.98	546.10	532.61
24	186.75	0.0	608.34	628.47	656.41	654.85	653.23	650.23	646.58	642.06	636.40	629.39	614.35	596.91
25	187.25	0.0	607.94	628.02	660.18	659.17	658.01	655.73	652.99	649.40	644.60	638.25	623.80	606.16
26	187.75	0.0	608.79	628.66	664.28	663.71	662.88	661.26	659.54	657.00	653.14	647.54	633.77	615.94
27	188.35	0.0	609.80	629.42	667.14	667.32	667.42	667.63	667.44	666.34	663.81	659.27	646.51	628.47
28	188.95	0.0	611.01	630.24	670.15	670.92	671.65	673.70	675.23	675.82	674.87	671.66	660.25	642.06
29	189.55	0.0	612.27	630.94	672.94	674.23	675.50	679.36	682.76	685.26	686.23	684.76	675.25	657.03
30	190.15	0.0	613.42	631.34	675.16	676.94	678.72	684.39	689.78	694.45	697.73	698.68	691.95	673.87
31	190.75	0.0	614.28	631.22	676.48	678.73	681.02	688.48	695.97	703.04	709.06	713.58	711.12	693.37
32	191.50	0.0	614.88	628.93	675.79	679.09	682.49	694.03	706.48	719.46	731.92	741.13	740.57	723.09
33	192.25	0.0	611.23	621.94	668.06	672.23	676.56	691.57	708.51	727.38	747.59	766.46	775.11	761.02

IF-300 TRANSFER CASE ETAS1 MODEL RUN 10, 4 CASES, NEW K -- POSTFIRE TR

TRANSIENT TEMPERATURE DISTRIBUTION AFTER 147 TIME STEPS, TIME = 5.00000D+01

GROSS GRID						6 I	7 I
FINE GRID		14	15	16	17	18	19
	DISTANCE	25.98	27.21	28.45	29.68	30.91	31.03
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.75	0.0	0.0	0.0	0.0	0.0	0.0
3	1.50	0.0	0.0	0.0	0.0	0.0	0.0
4	2.25	0.0	0.0	0.0	0.0	0.0	0.0
5	3.00	0.0	0.0	0.0	0.0	0.0	0.0
6	3.75	0.0	0.0	0.0	0.0	0.0	0.0
7	4.50	0.0	0.0	0.0	0.0	0.0	0.0
8	5.25	0.0	0.0	0.0	0.0	0.0	0.0
9	5.88	0.0	0.0	0.0	0.0	0.0	0.0
10	6.50	0.0	0.0	0.0	0.0	0.0	0.0
11	19.38	329.20	263.76	241.61	246.96	282.31	281.85
12	32.25	376.80	347.35	319.85	294.05	269.50	269.14
13	45.13	369.15	342.21	316.25	291.14	266.76	266.42
14	58.00	369.91	342.81	316.73	291.54	267.11	266.77
15	70.88	370.88	343.60	317.37	292.04	267.47	267.12
16	83.75	371.39	344.03	317.72	292.30	267.66	267.31
17	96.63	371.52	344.14	317.81	292.37	267.71	267.36
18	109.50	371.31	343.97	317.67	292.26	267.63	267.28
19	122.37	370.77	343.52	317.31	291.98	267.42	267.08
20	135.25	370.64	343.46	317.26	291.91	267.31	266.96
21	148.12	379.21	349.33	321.44	295.29	270.42	270.05
22	161.00	329.90	264.16	241.94	247.41	283.11	282.65
23	173.87	0.0	0.0	0.0	0.0	0.0	0.0
24	186.75	0.0	0.0	0.0	0.0	0.0	0.0
25	187.25	0.0	0.0	0.0	0.0	0.0	0.0
26	187.75	0.0	0.0	0.0	0.0	0.0	0.0
27	188.35	0.0	0.0	0.0	0.0	0.0	0.0
28	188.95	0.0	0.0	0.0	0.0	0.0	0.0
29	189.55	0.0	0.0	0.0	0.0	0.0	0.0
30	190.15	0.0	0.0	0.0	0.0	0.0	0.0
31	190.75	0.0	0.0	0.0	0.0	0.0	0.0
32	191.50	0.0	0.0	0.0	0.0	0.0	0.0
33	192.25	0.0	0.0	0.0	0.0	0.0	0.0

IF-300 TRANSFER CASK ETAS1 MODEL RUN 10, 4 CASES, NEW K -- POSTFIRE TR

TRANSIENT TEMPERATURE DISTRIBUTION AFTER 154 TIME STEPS, TIME = 6.00000D+01

GROSS GRID		1 I			2 I		3 I					4 I		5 I
FINE GRID		1	2	3	4	5	6	7	8	9	10	11	12	13
	DISTANCE	-6.25	6.25	12.50	18.75	19.00	19.25	20.05	20.85	21.65	22.45	23.25	24.00	24.75
1	0.0	0.0	555.44	570.07	619.71	623.26	626.92	639.33	652.73	666.76	680.39	690.73	691.57	676.78
2	0.75	0.0	564.84	582.73	630.09	632.81	635.57	644.74	654.13	663.21	670.88	674.81	670.67	654.71
3	1.50	0.0	570.41	591.05	634.25	636.03	637.81	643.46	648.74	653.21	656.30	657.53	652 42	636 47
4	2.25	0.0	572.21	593.97	634.26	635.55	636.81	640.64	643.88	646.16	646.98	645.75	637 52	621.34
5	3.00	0.0	573.20	595.83	632.93	633.75	634.52	636.64	638.07	638.48	637.48	634.58	624 46	608 21
6	3 75	0.0	573.62	596.91	630.69	631.03	631.31	631.80	631 60	630.44	627 99	623 90	612 52	596 35
7	4.50	0.0	573 67	597.46	627.96	627.77	627.49	626.36	624.70	622.22	618.61	613.60	601 37	585.35
8	5.25	0.0	573.52	597.73	625.22	624.26	623.09	620.37	617.49	613.93	609 39	603.67	590 81	574.99
9	5.88	0.0	573.51	598.17	620.96	619.57	618 00	614.91	611.33	607.04	601.87	595.68	582 40	566 79
10	6.50	0.0	574.38	599.16	616.39	614.70	612 85	609.32	605.15	600.26	594 55	587.95	574 35	558.94
11	19.38	0.0	0.0	0.0	509.64	509.01	508.26	506.65	504.61	502.13	499.22	495.90	489 01	480 96
12	32.25	0.0	0.0	0.0	419.79	419.22	418.68	417.76	416.74	415.62	414.39	413.05	410 60	408 22
13	45.13	0.0	0.0	0.0	404.53	403.95	403.39	402.45	401.52	400.58	399.61	398.60	396 70	394.65
14	58.00	0.0	0.0	0.0	404.78	404.20	403.62	402.67	401.75	400.83	399.90	398.94	397 12	395.09
15	70.88	0.0	0.0	0.0	405.89	405.31	404.74	403.79	402.86	401.94	401.01	400.05	398.23	396 19
16	83.75	0.0	0.0	0.0	406.52	405.94	405.36	404.41	403.48	402.56	401.62	400 66	398 83	396 79
17	96.63	0.0	0.0	0.0	406.68	406.10	405.52	404.57	403.64	402.72	401.78	400.82	398.99	396.94
18	109.50	0.0	0.0	0.0	406.43	405.85	405.27	404.32	403.39	402.47	401.53	400.58	398.74	396 70
19	122.37	0.0	0.0	0.0	405.82	405.24	404.66	403.72	402.79	401.86	400.93	399 97	398.14	396.10
20	135.25	0.0	0.0	0.0	406.35	405.77	405.20	404.27	403.33	402.38	401.41	400.39	398.47	396 40
21	148.12	0.0	0.0	0.0	422.53	421.96	421.42	420.49	419.47	418.35	417.12	415.77	413 32	410.92
22	161.00	0.0	0.0	0.0	508.67	508.04	507.25	505.62	503.61	501.21	498.44	495.30	488.68	480.73
23	173.87	0.0	0.0	0.0	562.72	562.05	561.14	558.99	556.03	552.27	547.73	542.43	531.31	518.26
24	186.75	0.0	616.11	633.11	645.75	644.33	642.67	639.34	635.25	630.30	624.39	617.43	602.81	585.95
25	187.25	0.0	614.86	631.81	647.92	646.67	645.24	642.36	638.89	634.58	629.26	622 77	608.60	591.66
26	187.75	0.0	613.24	629.98	649.46	648.65	647.66	645.26	642.48	638.90	634.24	628.28	614.62	597 61
27	188.35	0.0	611.88	628.43	650.19	649.92	649.60	648.38	646.66	644.08	640.33	635.11	622.19	605.12
28	188.95	0.0	610.09	626.42	650.69	650.86	650.98	651.07	650.58	649.18	646.52	642.19	630.22	613.13
29	189.55	0.0	607.82	623.84	650.73	651.29	651.83	653.27	654.14	654.11	652.74	649.53	638.82	621.79
30	190.15	0.0	604.99	620.60	650.09	651.05	651.99	654.84	657.23	658.76	658.94	657.17	648.22	631.37
31	190.75	0.0	601.52	616.60	648.55	649.91	651.28	655.62	659.66	662.99	665.01	665.15	658.83	642.26
32	191.50	0.0	590.93	604.30	641.15	643.45	645.82	653.72	661.94	669.95	676.67	679.74	674.88	658.50
33	192.25	0.0	576.34	587.55	627.63	630.79	634.07	645.28	657.57	670.64	683.47	693.16	693 54	678.52

IF-300 TRANSFER CASK ETAS1 MODEL RUN 10, 4 CASES, NEW K -- POSTFIRE TR

TRANSIENT TEMPERATURE DISTRIBUTION AFTER 154 TIME STEPS, TIME = 6.00000D+01

GROSS GRID						6 I	7 I
FINE GRID		14	15	16	17	18	19
	DISTANCE	25.98	27.21	28.45	29.68	30.91	31.03
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.75	0.0	0.0	0.0	0.0	0.0	0.0
3	1.50	0.0	0.0	0.0	0.0	0.0	0.0
4	2.25	0.0	0.0	0.0	0.0	0.0	0.0
5	3.00	0.0	0.0	0.0	0.0	0.0	0.0
6	3.75	0.0	0.0	0.0	0.0	0.0	0.0
7	4.50	0.0	0.0	0.0	0.0	0.0	0.0
8	5.25	0.0	0.0	0.0	0.0	0.0	0.0
9	5.88	0.0	0.0	0.0	0.0	0.0	0.0
10	6.50	0.0	0.0	0.0	0.0	0.0	0.0
11	19.38	324.61	260.35	237.21	239.20	266.92	266.51
12	32.25	372.91	339.75	308.80	279.82	252.38	252.05
13	45.13	362.90	332.50	303.33	275.30	248.31	248.00
14	58.00	363.16	332.67	303.48	275.47	248.52	248.22
15	70.88	364.08	333.44	304.11	275.97	248.91	248.60
16	83.75	364.60	333.87	304.47	276.25	249.12	248.81
17	96.63	364.73	333.99	304.56	276.33	249.18	248.87
18	109.50	364.53	333.81	304.42	276.21	249.09	248.78
19	122.37	364.02	333.40	304.08	275.94	248.87	248.57
20	135.25	364.40	333.76	304.37	276.13	248.92	248.61
21	148.12	375.19	341.65	310.38	281.09	253.37	253.03
22	161.00	324.58	260.39	237.30	239.36	267.22	266.81
23	173.87	0.0	0.0	0.0	0.0	0.0	0.0
24	186.75	0.0	0.0	0.0	0.0	0.0	0.0
25	187.25	0.0	0.0	0.0	0.0	0.0	0.0
26	187.75	0.0	0.0	0.0	0.0	0.0	0.0
27	188.35	0.0	0.0	0.0	0.0	0.0	0.0
28	188.95	0.0	0.0	0.0	0.0	0.0	0.0
29	189.55	0.0	0.0	0.0	0.0	0.0	0.0
30	190.15	0.0	0.0	0.0	0.0	0.0	0.0
31	190.75	0.0	0.0	0.0	0.0	0.0	0.0
32	191.50	0.0	0.0	0.0	0.0	0.0	0.0
33	192.25	0.0	0.0	0.0	0.0	0.0	0.0

IF-300 TRANSFER CASK ETAS1 MODEL RUN 10, 4 CASES, NEW K -- POSTFIRE TR

TRANSIENT TEMPERATURE DISTRIBUTION AFTER 206 TIME STEPS, TIME = 2.10000D+02

GROSS GRID		1 I			2 I		3 I					4 I		5 I
FINE GRID		1	2	3	4	5	6	7	8	9	10	11	12	13
	DISTANCE	-6.25	6.25	12.50	18.75	19.00	19.25	20.05	20.85	21.65	22.45	23.25	24.00	24.75
1	0.0	0.0	353.04	353.87	351.48	351.11	350.72	349.29	347.52	345.29	342.43	338.74	334.44	329.67
2	0.75	0.0	364.68	364.95	361.50	361.07	360.61	358.99	357.03	354.60	351.54	347.61	342.86	337.76
3	1.50	0.0	374.84	374.57	370.18	369.71	369.22	367.50	365.45	363.00	360.01	356.13	350.35	344.83
4	2.25	0.0	379.55	379.02	374.27	373.80	373.31	371.59	369.57	367.22	364.52	361.54	356.27	350.66
5	3.00	0.0	383.75	383.03	378.07	377.61	377.14	375.47	373.54	371.32	368.85	366.23	361.22	355.53
6	3.75	0.0	387.45	386.58	381.55	381.13	380.69	379.13	377.30	375.21	372.88	370.41	365.49	359.71
7	4.50	0.0	390.62	389.67	384.71	384.33	383.95	382.56	380.84	378.85	376.61	374.20	369.28	363.40
8	5.25	0.0	393.28	392.29	387.49	387.19	386.92	385.80	384.18	382.25	380.06	377.66	372.70	366.71
9	5.88	0.0	396.51	395.50	391.03	390.45	389.78	388.47	386.83	384.91	382.73	380.34	375.32	369.24
10	6.50	0.0	398.57	397.55	393.65	393.10	392.42	391.01	389.34	387.41	385.24	382.84	377.77	371.60
11	19.38	0.0	0.0	0.0	411.04	410.42	409.70	408.33	406.74	404.94	402.95	400.76	396.31	391.18
12	32.25	0.0	0.0	0.0	412.23	411.63	411.02	409.96	408.89	407.80	406.70	405.59	403.52	401.28
13	45.13	0.0	0.0	0.0	399.84	399.25	398.66	397.64	396.60	395.54	394.45	393.33	391.29	389.19
14	58.00	0.0	0.0	0.0	394.19	393.59	393.00	391.98	390.96	389.91	388.85	387.77	385.80	383.77
15	70.88	0.0	0.0	0.0	393.10	392.50	391.91	390.89	389.87	388.83	387.78	386.72	384.78	382.77
16	83.75	0.0	0.0	0.0	393.21	392.62	392.02	391.00	389.98	388.94	387.89	386.83	384.90	382.89
17	96.63	0.0	0.0	0.0	393.36	392.77	392.17	391.15	390.13	389.09	388.04	386.98	385.05	383.04
18	109.50	0.0	0.0	0.0	393.57	392.98	392.38	391.36	390.34	389.30	388.25	387.18	385.24	383.22
19	122.37	0.0	0.0	0.0	394.98	394.39	393.79	392.78	391.75	390.70	389.63	388.55	386.58	384.54
20	135.25	0.0	0.0	0.0	400.59	400.00	399.41	398.39	397.35	396.28	395.19	394.08	392.04	389.93
21	148.12	0.0	0.0	0.0	411.63	411.04	410.43	409.37	408.30	407.21	406.12	405.01	402.95	400.72
22	161.00	0.0	0.0	0.0	409.18	408.56	407.86	406.50	404.91	403.10	401.08	398.84	394.35	389.24
23	173.87	0.0	0.0	0.0	407.52	406.87	406.10	404.54	402.64	400.42	397.89	395.05	389.21	382.44
24	186.75	0.0	391.84	392.25	392.17	391.70	391.07	389.76	388.17	386.32	384.22	381.90	376.95	370.84
25	187.25	0.0	390.27	390.67	389.81	389.35	388.80	387.62	386.07	384.21	382.09	379.75	374.83	368.78
26	187.75	0.0	387.91	388.30	386.80	386.58	386.40	385.40	383.86	381.98	379.82	377.47	372.56	366.58
27	188.35	0.0	385.99	386.39	384.54	384.24	383.93	382.72	381.11	379.16	376.94	374.53	369.62	363.72
28	188.95	0.0	383.72	384.14	382.03	381.68	381.31	379.94	378.23	376.18	373.86	371.35	366.38	360.56
29	189.55	0.0	381.08	381.56	379.30	378.92	378.51	377.03	375.22	373.06	370.57	367.88	362.76	357.00
30	190.15	0.0	378.09	378.65	376.36	375.96	375.53	373.99	372.10	369.82	367.12	364.04	358.65	352.94
31	190.75	0.0	374.74	375.41	373.23	372.82	372.39	370.82	368.90	366.53	363.58	359.68	353.85	348.22
32	191.50	0.0	365.57	366.55	364.86	364.47	364.06	362.55	360.66	358.28	355.22	351.24	346.42	341.19
33	192.25	0.0	354.81	356.10	355.08	354.74	354.17	353.01	351.29	349.07	346.18	342.43	338.03	333.13

IF-300 TRANSFER CASK ETAS1 MODEL RUN 10, 4 CASES, NEW K -- POSTFIRE TR

TRANSIENT TEMPERATURE DISTRIBUTION AFTER 206 TIME STEPS, TIME = 2.10000D+02

GROSS GRID						6 I	7 I
FINE GRID		14	15	16	17	18	19
	DISTANCE	25.98	27.21	28.45	29.68	30.91	31.03
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.75	0.0	0.0	0.0	0.0	0.0	0.0
3	1.50	0.0	0.0	0.0	0.0	0.0	0.0
4	2.25	0.0	0.0	0.0	0.0	0.0	0.0
5	3.00	0.0	0.0	0.0	0.0	0.0	0.0
6	3.75	0.0	0.0	0.0	0.0	0.0	0.0
7	4.50	0.0	0.0	0.0	0.0	0.0	0.0
8	5.25	0.0	0.0	0.0	0.0	0.0	0.0
9	5.88	0.0	0.0	0.0	0.0	0.0	0.0
10	6.50	0.0	0.0	0.0	0.0	0.0	0.0
11	19.38	285.65	240.07	221.95	219.86	232.46	232.22
12	32.25	365.38	331.93	300.82	271.77	244.40	244.09
13	45.13	356.65	325.58	295.86	267.38	240.05	239.76
14	58.00	351.99	321.64	292.61	264.78	238.06	237.78
15	70.88	351.09	320.86	291.96	264.27	237.71	237.43
16	83.75	351.18	320.93	292.02	264.33	237.76	237.49
17	96.63	351.31	321.04	292.11	264.40	237.81	237.54
18	109.50	351.48	321.20	292.24	264.50	237.88	237.60
19	122.37	352.65	322.20	293.07	265.15	238.34	238.07
20	135.25	357.28	326.11	296.30	267.74	240.33	240.05
21	148.12	364.91	331.53	300.49	271.50	244.19	243.88
22	161.00	284.76	239.58	221.57	219.41	231.68	231.45
23	173.87	0.0	0.0	0.0	0.0	0.0	0.0
24	186.75	0.0	0.0	0.0	0.0	0.0	0.0
25	187.25	0.0	0.0	0.0	0.0	0.0	0.0
26	187.75	0.0	0.0	0.0	0.0	0.0	0.0
27	188.35	0.0	0.0	0.0	0.0	0.0	0.0
28	188.95	0.0	0.0	0.0	0.0	0.0	0.0
29	189.55	0.0	0.0	0.0	0.0	0.0	0.0
30	190.15	0.0	0.0	0.0	0.0	0.0	0.0
31	190.75	0.0	0.0	0.0	0.0	0.0	0.0
32	191.50	0.0	0.0	0.0	0.0	0.0	0.0
33	192.25	0.0	0.0	0.0	0.0	0.0	0.0

IF-300 TRANSFER CASE ETAS1 MODEL RUN 10, 4 CASES, NEW E -- FINAL SS

STEADY STATE TEMPERATURE DISTRIBUTION AFTER 11 ITERATIONS, TIME = 2.10000D+02

GROSS GRID		1 I			2 I		3 I					4 I		5 I
FINE GRID		1	2	3	4	5	6	7	8	9	10	11	12	13
	DISTANCE	-6.25	6.25	12.50	18.75	19.00	19.25	20.05	20.85	21.65	22.45	23.25	24.00	24.75
1	0.0	0.0	176.18	178.29	181.54	181.57	181.59	181.62	181.57	181.41	181.16	180.83	180.52	180.32
2	0.75	0.0	178.60	180.91	184.52	184.56	184.59	184.62	184.57	184.40	184.12	183.72	183.31	183.06
3	1.50	0.0	180.98	183.49	187.56	187.61	187.64	187.70	187.66	187.50	187.19	186.65	185.96	185.62
4	2.25	0.0	182.31	184.94	189.36	189.41	189.46	189.54	189.52	189.38	189.13	188.79	188.28	187 93
5	3.00	0.0	183.59	186.34	191.23	191.30	191.35	191.48	191.48	191.37	191.16	190.89	190.46	190 09
6	3.75	0.0	184.81	187.67	193.16	193.25	193.33	193.51	193 53	193.44	193.25	193.01	192 58	192.18
7	4.50	0.0	185.98	188.94	195.16	195.30	195.42	195.67	195.70	195.59	195.39	195.14	194 70	194 26
8	5.25	0.0	187.09	190.12	197.21	197.44	197.70	198 00	197 98	197.82	197.59	197 31	196 82	196.33
9	5.88	0.0	188.64	191.74	200.19	200.20	200.21	200.16	199.98	199.74	199.45	199 14	198 61	198.07
10	6.50	0.0	190.14	193.27	203.30	203.04	202 79	202.39	202.03	201 68	201.33	200.98	200 40	199.82
11	19.38	0.0	0.0	0.0	246.82	246.24	245.66	244.67	243.74	242.87	242.04	241.25	240.00	238.79
12	32.25	0.0	0.0	0.0	282.75	282.17	281 60	280.66	279.80	279.03	278.34	277 73	276.81	275 96
13	45.13	0.0	0 0	0.0	304.17	303.59	303.01	302.06	301.18	300.36	299.61	298 92	297 82	296 78
14	58.00	0.0	0.0	0.0	316.47	315.88	315 31	314.35	313 45	312.61	311 81	311.07	309 85	308 69
15	70.88	0.0	0.0	0.0	323.18	322.60	322.02	321.06	320.15	319.29	318.47	317.69	316.41	315 18
16	83.75	0.0	0.0	0.0	326.26	325.68	325.10	324.14	323.23	322.35	321.52	320.73	319 42	318 16
17	96.63	0.0	0.0	0.0	326.63	326.05	325.47	324.51	323.59	322.72	321.89	321.10	319.78	318 52
18	109.50	0.0	0.0	0.0	324.39	323.80	323.23	322.27	321.35	320.49	319.66	318 88	317.59	316.35
19	122.37	0.0	0.0	0.0	318.87	318.29	317.71	316.75	315.85	315.00	314.19	313.44	312.20	311.01
20	135.25	0.0	0.0	0.0	308.47	307.88	307.31	306.36	305.47	304.64	303.87	303.16	302.02	300.94
21	148.12	0.0	0.0	0.0	290.18	289.60	289.03	288.08	287.21	286.42	285.71	285.07	284.08	283.16
22	161.00	0.0	0.0	0.0	259.61	259.02	258.44	257.43	256.45	255.49	254.56	253.64	252.14	250.68
23	173.87	0.0	0.0	0.0	231.15	230.57	230.00	228.99	228.04	227.15	226.29	225 48	224.19	222.95
24	186.75	0.0	185.85	188.52	196.89	196.58	196.30	195.85	195.46	195.12	194.79	194.50	194.04	193.61
25	187.25	0.0	184.65	187.31	194.55	194.51	194.46	194.30	194.06	193.78	193.50	193.23	192.80	192.39
26	187.75	0.0	183.43	186.05	192.31	192.47	192.66	192.79	192.67	192.46	192.21	191.95	191.55	191.17
27	188.35	0.0	182.56	185.14	190.79	190.89	190.98	191.11	191.05	190.89	190.66	190.42	190.04	189.69
28	188.95	0.0	181.66	184.18	189.30	189.38	189.44	189.54	189.50	189.35	189.14	188.89	188.51	188.19
29	189.55	0.0	180.73	183.18	187.86	187.92	187.97	188.04	188.00	187.85	187.63	187 35	186.95	186.65
30	190.15	0.0	179.77	182.14	186.47	186.52	186.56	186.61	186.56	186.41	186.15	185 81	185.33	185.04
31	190.75	0.0	178.77	181.07	185.12	185.17	185.20	185.24	185.18	185.02	184.73	184.22	183.60	183 31
32	191.50	0.0	176.56	178.68	182.28	182.31	182.34	182.36	182.30	182.14	181.87	181.51	181.15	180.95
33	192.25	0.0	174.31	176.25	179.49	179.52	179.54	179.56	179.50	179.35	179.12	178.81	178.54	178.39

IF-300 TRANSFER CASE ETAS1 MODEL RUN 10, 4 CASES, NEW E -- FINAL SS

STEADY STATE TEMPERATURE DISTRIBUTION AFTER 11 ITERATIONS, TIME = 2.10000D+02

GROSS GRID						6 I	7 I
FINE GRID		14	15	16	17	18	19
	DISTANCE	25.98	27.21	28.45	29.68	30.91	31 03
1	0.0	0.0	0.0	0.0	0.0	0.0	0 0
2	0.75	0.0	0.0	0.0	0.0	0.0	0 0
3	1.50	0.0	0.0	0.0	0.0	0.0	0 0
4	2.25	0.0	0.0	0.0	0.0	0.0	0 0
5	3.00	0.0	0.0	0.0	0.0	0.0	0 0
6	3.75	0.0	0.0	0.0	0.0	0.0	0 0
7	4.50	0.0	0.0	0.0	0.0	0.0	0 0
8	5.25	0.0	0.0	0.0	0.0	0.0	0 0
9	5.88	0.0	0.0	0.0	0.0	0.0	0 0
10	6.50	0.0	0.0	0.0	0.0	0.0	0 0
11	19.38	214.06	202.09	196.08	192.87	190.95	190 90
12	32.25	259.40	243.86	229.24	215.43	202.30	202 19
13	45.13	277.38	258.96	241.40	224.64	208.60	208 47
14	58.00	287.55	267.44	248.24	229.89	212.31	212 16
15	70.88	293.10	272.07	251.99	232.79	214.38	214 21
16	83.75	295.65	274.21	253.72	234.12	215.33	215 17
17	96.63	295.96	274.46	253.93	234.28	215.45	215 28
18	109.50	294.10	272.91	252.67	233.31	214.75	214 59
19	122.37	289.54	269.09	249.59	230.93	213.05	212 89
20	135.25	280.93	261.91	243.78	226.47	209.89	209 75
21	148.12	265.43	248.79	233.16	218.41	204.40	204.28
22	161.00	219.80	205.11	198.00	194.67	193.50	193.43
23	173.87	0.0	0.0	0.0	0.0	0.0	0 0
24	186.75	0.0	0.0	0.0	0.0	0.0	0.0
25	187.25	0.0	0.0	0.0	0.0	0.0	0.0
26	187.75	0.0	0.0	0.0	0.0	0.0	0.0
27	188.35	0.0	0.0	0.0	0.0	0.0	0.0
28	188.95	0.0	0.0	0.0	0.0	0.0	0.0
29	189.55	0.0	0.0	0.0	0.0	0.0	0.0
30	190.15	0.0	0.0	0.0	0.0	0.0	0.0
31	190.75	0.0	0.0	0.0	0.0	0.0	0.0
32	191.50	0.0	0.0	0.0	0.0	0.0	0.0
33	192.25	0.0	0.0	0.0	0.0	0.0	0.0

2. HEATING6 Input File Listings

HEATING6 Input for Argon Filled Cask During LOMC

```
 &OPTION MAXBDC=7,NDIMEN=2,MAXGGL=45,MAXPBT=1,MAXPRS=17,
@MAXPTS=1000,MAXREG=105,MAXRPG=25,MAXSUR=1000,MAXTPG=50,
@MAXANA=1,MAXHGN=1,MAXMAT=5,
@MAXZPG=1,MWIDTH=1000,DIRECT=T,LBOUND=T,&END
 17 ELEM IF-300 BASKET, ARGON, TSHELL 229.0, LOMC, INITIAL, RUN 1
300 7 1 0.0 0.0 0.0 1 0
0 0 0 0 0 0 0 0 200
REGIONS
*
*    FUEL REGIONS
*
1   1               0.000  2.639  11.575  16.853
 3   1   2 0 0 0
2   1               0.000  2.639  4.800   10.078
 3   1   2 0 0 0
3   1               0.000  2.639 -1.970   3.308
 3   1   2 0 0 0
4   1               0.000  2.639 -8.740  -3.462
 3   1   2 0 0 0
5   1               0.000  2.639 -15.515 -10.237
 3   1   2 0 0 0
6   1               4.581  9.859  8.193   13.471
 3   1   0 0 0 0
7   1               4.581  9.859  1.418   6.696
 3   1   0 0 0 0
8   1               4.581  9.859 -5.358  -0.080
 3   1   0 0 0 0
9   1               4.581  9.859 -12.133 -6.855
 3   1   0 0 0 0
10  1               11.306 16.584 1.418   6.696
 3   1   0 0 0 0
11  1               11.306 16.584 -5.358 -0.080
 3   1   0 0 0 0
*
*    POISON REGIONS
*
14  2               3.485  3.735 -15.595  16.933
 2   0   0 0 2 2
15  2               10.455 10.705 -12.213 13.551
 2   0   0 0 2 2
*
*    CHANNEL REGIONS
*
16  3               0.000  2.639  11.495   11.575
 2   0   2 0 0 0
17  3               2.639  2.719  11.495   16.933
 2   0   0 0 0 0
18  3               0.000  2.639  16.853   16.933
 2   0   2 0 0 0
19  3               0.000  2.639  4.720    4.800
 2   0   2 0 0 0
20  3               2.639  2.719  4.720    10.158
 2   0   0 0 0 0
21  3               0.000  2.639  10.078   10.158
 2   0   2 0 0 0
22  3               0.000  2.639 -2.050   -1.970
 2   0   2 0 0 0
23  3               2.639  2.719 -2.050    3.388
 2   0   0 0 0 0
24  3               0.000  2.639  3.308    3.388
 2   0   2 0 0 0
25  3               0.000  2.639 -8.820   -8.740
 2   0   2 0 0 0
26  3               2.639  2.719 -8.820   -3.382
 2   0   0 0 0 0
27  3               0.000  2.639 -3.462   -3.382
 2   0   2 0 0 0
28  3               0.000  2.639 -15.595  -15.515
 2   0   2 0 0 0
29  3               2.639  2.719 -15.595  -10.157
 2   0   0 0 0 0
30  3               0.000  2.639 -10.237  -10.157
 2   0   2 0 0 0
31  3               4.501  4.581  8.113    13.551
 2   0   0 0 0 0
32  3               4.581  9.859  8.113    8.193
 2   0   0 0 0 0
33  3               9.859  9.939  8.113    13.551
 2   0   0 0 0 0
34  3               4.581  9.859  13.471   13.551
 2   0   0 0 0 0
35  3               4.501  4.581  1.338    6.776
 2   0   0 0 0 0
36  3               4.581  9.859  1.338    1.418
 2   0   0 0 0 0
37  3               9.859  9.939  1.338    6.776
 2   0   0 0 0 0
38  3               4.581  9.859  6.696    6.776
 2   0   0 0 0 0
39  3               4.501  4.581 -5.438    0.000
 2   0   0 0 0 0
40  3               4.581  9.859 -5.438   -5.358
 2   0   0 0 0 0
41  3               9 859  9.939 -5.438    0.000
 2   0   0 0 0 0
42  3               4.581  9.859 -0.080    0.000
 2   0   0 0 0 0
43  3               4 501  4.581 -12.213  -6.775
 2   0   0 0 0 0
44  3               4.581  9 859 -12.213  -12.133
 2   0   0 0 0 0
45  3               9.859  9 939 -12.213  -6.775
 2   0   0 0 0 0
46  3               4 581  9 859 -6 855   -6.775
 2   0   0 0 0 0
47  3               11.226 11.306 1.338    6.776
 2   0   0 0 0 0
48  3               11 306 16 584 1.338    1.418
 2   0   0 0 0 0
49  3               16 584 16.664 1.338    6.776
 2   0   0 0 0 0
50  3               11.306 16.584 6 696    6.776
 2   0   0 0 0 0
```

```
51  3                11.226 11.306 -5.438   0.000
 2   0    0 0 0 0
52  3                11.306 16.584 -5.438  -5.358
 2   0    0 0 0 0
53  3                16.584 16.664 -5.438   0.000
 2   0    0 0 0 0
54  3                11.306 16.584 -0.080   0.000
 2   0    0 0 0 0
*
*     OUTSIDE GAP REGIONS
*
101 4                0.000  2.719  16.933  19.680
 1   0    2 2 4 4
102 4                3.735  11.226 13.551  16.933
 1   0    6 6 4 4
103 4                10.705 11.306 13.471  13.551
 1   0    6 6 0 0
104 4                10.705 16.584 8.113   13.471
 1   0    6 6 5 5
105 4                10.705 18.750 6.776   8.113
 1   0    6 6 7 7
106 4                16.664 18.750 1.338   6.776
 1   0    4 4 0 0
107 4                16.664 18.750 -5.438  0.000
 1   0    4 4 0 0
108 4                10.705 18.750 -6.775 -5.438
 1   0    6 6 7 7
109 4                10.705 16.584 -12.133 -6.775
 1   0    6 6 5 5
110 4                10.705 11.306 -12.213 -12.133
 1   0    6 6 0 0
111 4                3.735  11.226 -15.595 -12.213
 1   0    6 6 4 4
112 4                0.000  2.719  -17.820 -15.595
 1   0    2 2 4 4
*
*     INSIDE GAP REGIONS
*
201 4                2.719    3.485  11.495  16.933
 2   0    4 4 0 2
202 4                0.000    3.485  10.158  11.495
 2   0    2 0 3 3
203 4                2.719    3.485  4.720   10.158
 2   0    4 4 0 0
204 4                3.735    4.501  8.113   13.551
 2   0    4 4 0 0
205 4                3.735    4.501  1.338   6.776
 2   0    4 4 0 0
206 4                0.000    3.485  3.388   4.720
 2   0    2 0 3 3
207 4                9.939    10.455 8.113   13.551
 2   0    4 4 0 0
208 4                3.735    10.455 6.776   8.113
 2   0    6 6 3 3
209 4                9.939    10.455 1.338   6.776
 2   0    4 4 0 0
210 4                10.705   11.226 1.338   6.776
 2   0    4 4 0 0
211 4                2.719    3.485 -2.050   3.388
 2   0    4 4 0 0
212 4                3.735    10.455 0.000   1.338
 2   0    6 6 3 3
213 4                10.705   18.750 0.000   1.338
 2   0    6 6 3 3
 214 4                 3.735   4.501 -5.438   0.000
 2   0    4 4 0 0
215 4                0.000    3.485 -3.382  -2.050
 2   0    2 0 3 3
216 4                2.719    3.485 -8.820  -3.382
 2   0    4 4 0 0
217 4                9.939    10.455 -5.438  0.000
 2   0    4 4 0 0
218 4                10.705   11.226 -5.438  0.000
 2   0    4 4 0 0
219 4                3.735    10.455 -6.775  -5.438
 2   0    6 6 3 3
220 4                0.000    3.485  -10.157 -8.820
 2   0    2 0 3 3
221 4                3.735    4.501  -12.213 -6.775
 2   0    4 4 0 0
222 4                2.719    3.485  -15.595 -10.157
 2   0    4 4 2 0
223 4                9.939    10.455 -12.213 -6.775
 2   0    4 4 0 0
```

```
*
*     SHELL REGIONS
*
301 S              0.000    2.719   19.680   20.180
 1   0   2 2 0 1
302 S              4.501    11.226  16.933   17.433
 1   0   2 2 0 1
303 S              11.226   11.306  13.551   16.933
 1   0   0 1 2 2
304 S              11.306   16.584  13.471   13.551
 1   0   2 2 0 1
305 S              16.584   16.664  8.113    13.471
 1   0   0 1 2 2
306 S              18.750   19.250 -6.775    8.113
 1   0   0 1 2 2
307 S              16.584   16.664 -12.133  -6.775
 1   0   0 1 2 2
308 S              11.306   16.584 -12.213  -12.133
 1   0   2 2 1 0
309 S              11.226   11.306 -15.595  -12.213
 1   0   0 1 2 2
310 S              4.501    11.226 -16.095  -15.595
 1   0   2 2 1 0
311 S              0.000    2.719  -18.320  -17.820
 1   0   2 2 1 0
*
*
*
MATERIALS
*
*     SPECIFIC HEAT AND DENSITY VALUES ARE NOT REQUIRED
*     FOR A STEADY STATE ANALYSIS
*
1 FUEL 0 0 0 -6
2 NSORB 0 0 0 -2
*
*     NSORB ASSUMED TO HAVE THE SAME PROPERTIES AS SS304
*
3 ZIRCALOY  0 0 0 -3
*
*     PROPERTIES OF ZIRCALOY-2 ARE USED FOR ZIRCALOY-4
*
4 ARGON 0 0 0 -1
5 SS304 0 0 0 -2
*
*
INITIAL TEMPERATURES
1 250.0
2 400.0
3 500.0
*
*
HEAT GENERATIONS
1 9.776D-3
*
*
BOUNDARY CONDITIONS
*
*     CONSTANT TEMPERATURE CONDITION ON SHELL
*
1 2 229.0

*
*     INSULATED SURFACE
*
2 0
 0.0 0.0 0.0 0.0 0.0 0
*
*     RADIATION BETWEEN ZIRCALOY AND ZIRCALOY
*
3 3
 0.0 5.005D-14 0.0 0.0 0.0 0
*
*     RADIATION BETWEEN ZIRCALOY AND STEEL
*
4 3
 0.0 6.246D-14 0.0 0.0 0.0 0
*
*     RADIATION BETWEEN STEEL AND GAS
*
5 3
 0.0 1.175D-13 0.0 0.0 0.0 0
*
*     RADIATION BETWEEN STEEL AND STEEL
*
6 3
 0.0 8.308D-14 0.0 0.0 0.0 0
*
*     RADIATION BETWEEN ZIRCALOY AND GAS
*
7 3
 0.0 8.008D-14 0.0 0.0 0.0 0
*
*
XGRID
0.0 2.639 2.719 3.485 3.735 4.501 4.581 9.059 9.939
*10.455 10.705 11.226 11.306 16.584 16.664 18.750 19.250
3 1 1 1 1 1 2 1 1 1 1 1 2 1 1 1
*
```

```
*
YGRID
-18.320 -17.820 -16.095 -15.595 -15.515 -12.213 -12.133
*-10.237 -10.157 -8.820 -8.740 -6.855 -6.775 -5.438 -5.358
*-3.462 -3.382 -2.050 -1.970 -0.080 0.000 1.338 1.418 3.308
*3.388 4.720 4.800 6.696 6.776 8.113 8.193 10.078 10.158
*11.495 11.575 13.471 13.551 16.853 16.933 17.433 19.680 20.180
1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1
*1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1
*
*
ANALYTICAL FUNCTIONS

TABULAR FUNCTIONS
*
*    K OF PURE ARGON, REF. LIENHARD
*
1 6
  100 1.461D-5  200  1.669D-5  300 1.864D-5
* 400 2.049D-5  500 2.224D-5  1000 2.981D-5
*
*    K OF SS304 AND NSORB, REF: ORNL/CSD/TM-149
*
2 17
 100 0.0121  150 0.0125  200 0.0129  250 0.0133
*300 0.0136  350 0.014   400 0.0144  450 0.0147  500 0 0151
*550 0.0154  600 0.0157  650 0.0161  700 0.0164  750 0.0164
*800 0.0169  850 0.0174  900 0.0176
*
*    K OF ZIRCALOY-2, REF: RUST
*
3 5
  100.00 0.009472  200.00 0.009569  400.00 0.009875
* 600.00 0.01024   800.00 0.01061
*
*    K EFFECTIVE OF FUEL REGION, REF: EMAD PG 139
*
4 7
  400.00 2.222D-3  500.00 3.056D-3  600.00 3.611D-3
* 700.00 4.444D-3  800.00 5.278D-3  900.00 6.389D-3
* 1000.0 7.639D-3
*
*
STEADY STATE PARAMETERS
-20 0.001
*
```

HEATING6 Input for Argon Replaced by Steel Case During LOMC

```
 &OPTION MAXBDC=7,NDIMEN=2,MAXGGL=45,MAXPBT=1,MAXPRS=17,
@MAXPTS=805,MAXREG=105,MAXRFG=25,MAXSUR=1000,MAXTFG=50,
@MAXANA=1,MAXHGN=1,MAXMAT=5,
@MAXZFG=1,MWIDTH=250,DIRECT=T,LBOUND=T,&END
 17 ELEM IF-300 BASKET, STEEL, TSHELL 229.0, LOMC, INITIAL, RUN 2
300 7 1 0.0 0.0 0.0 1 0
0 0 0 0 0 0 0 0 200
REGIONS
*
*    FUEL REGIONS
*
1   1               0 000  2.639  11.575  16.853
 3   1    2 0 0 0
2   1               0.000  2.639  4.800   10.078
 3   1    2 0 0 0
3   1               0.000  2.639 -1.970   3.308
 3   1    2 0 0 0
4   1               0.000  2 639 -8.740  -3.462
 3   1    2 0 0 0
5   1               0.000  2 639 -15.515 -10.237
 3   1    2 0 0 0
6   1               4.581  9.859  8.193   13.471
 3   1    0 0 0 0
7   1               4.581  9.859  1.418   6.696
 3   1    0 0 0 0
8   1               4.581  9.859 -5.358  -0.080
 3   1    0 0 0 0
9   1               4.581  9.859 -12.133 -6.855
 3   1    0 0 0 0
10  1               11.306 16.584 1.418   6.696
 3   1    0 0 0 0
11  1               11.306 16.584 -5.358 -0.080
 3   1    0 0 0 0
*
*     POISON REGIONS
*
14  2               3.485  3.735 -15.595  16.933
 2   0    0 0 2 2
15  2               10.455 10.705 -12.213 13.551
 2   0    0 0 2 2
*
*     CHANNEL REGIONS
*
16  3               0.000  2.639  11.495   11.575
 2   0    2 0 0 0
17  3               2.639  2.719  11.495   16.933
 2   0    0 0 0 0
18  3               0.000  2.639  16.853   16.933
 2   0    2 0 0 0
19  3               0.000  2.639  4.720    4.800
 2   0    2 0 0 0
20  3               2.639  2.719  4.720    10.158
 2   0    0 0 0 0
21  3               0.000  2.639  10.078   10.158
 2   0    2 0 0 0
22  3               0.000  2.639 -2.050   -1.970
 2   0    2 0 0 0
23  3               2.639  2.719 -2.050    3.388
 2   0    0 0 0 0
24  3               0.000  2.639  3.308    3.388
 2   0    2 0 0 0
25  3               0.000  2.639 -8.820   -8.740
 2   0    2 0 0 0
26  3               2.639  2.719 -8.820   -3.382
 2   0    0 0 0 0
27  3               0.000  2.639 -3.462   -3.382
 2   0    2 0 0 0
28  3               0.000  2.639 -15.595  -15.515
 2   0    2 0 0 0
29  3               2.639  2.719 -15.595  -10.157
 2   0    0 0 0 0
30  3               0.000  2.639 -10.237  -10.157
 2   0    2 0 0 0
31  3               4.501  4.581  8.113    13.551
 2   0    0 0 0 0
32  3               4.581  9.859  8.113    8.193
 2   0    0 0 0 0
33  3               9.859  9.939  8.113    13.551
 2   0    0 0 0 0
34  3               4.581  9.859  13.471   13.551
 2   0    0 0 0 0
35  3               4.501  4.581  1.338    6.776
 2   0    0 0 0 0
36  3               4.581  9.859  1.338    1.418
 2   0    0 0 0 0
37  3               9.859  9.939  1.338    6.776
 2   0    0 0 0 0
38  3               4.581  9.859  6.696    6.776
 2   0    0 0 0 0
39  3               4.501  4.581 -5.438    0.000
 2   0    0 0 0 0
40  3               4.581  9.859 -5.438   -5.358
 2   0    0 0 0 0
41  3               9.859  9.939 -5.438    0.000
 2   0    0 0 0 0
42  3               4.581  9.859 -0.080    0.000
 2   0    0 0 0 0
43  3               4.501  4 581 -12.213  -6.775
 2   0    0 0 0 0
44  3               4.581  9.859 -12.213  -12.133
 2   0    0 0 0 0
45  3               9 859  9 939 -12.213  -6.775
 2   0    0 0 0 0
46  3               4.581  9.859 -6.855   -6.775
 2   0    0 0 0 0
47  3               11.226 11 306 1.338    6.776
 2   0    0 0 0 0
48  3               11 306 16 584 1.338    1.418
 2   0    0 0 0 0
49  3               16 584 16 664 1.338    6.776
 2   0    0 0 0 0
50  3               11.306 16 584 6 696    6.776
 2   0    0 0 0 0
51  3               11.226 11 306 -5.438   0.000
 2   0    0 0 0 0
```

```
52  3              11.306 16.584 -5.438  -5.358
 2   0   0 0 0 0
53  3              16.584 16.664 -5.438   0.000
 2   0   0 0 0 0
54  3              11.306 16.584 -0.080   0.000
 2   0   0 0 0 0
*
*    OUTSIDE GAP REGIONS
*
101 5              0.000  2.719  16.933  19.680
 1   0   2 2 0 0
102 5              3.735  11.226 13.551  16.933
 1   0   0 0 0 0
103 5              10.705 11.306 13.471  13.551
 1   0   0 0 0 0
104 5              10.705 16.584 8.113   13.471
 1   0   0 0 0 0
105 5              10.705 18.750 6.776   8.113
 1   0   0 0 0 0
106 5              16.664 18.750 1.338   6.776
 1   0   0 0 0 0
107 5              16.664 18.750 -5.438  0.000
 1   0   0 0 0 0
108 5              10.705 18.750 -6.775 -5.438
 1   0   0 0 0 0
109 5              10.705 16.584 -12.133 -6.775
 1   0   0 0 0 0
110 5              10.705 11.306 -12.213 -12.133
 1   0   0 0 0 0
111 5              3.735  11.226 -15.595 -12.213
 1   0   0 0 0 0
112 5              0.000  2.719  -17.820 -15.595
 1   0   2 2 0 0
```

```
*
*     INSIDE GAP REGIONS
*
201 5              2.719    3.485  11.495  16.933
 2   0    0 0 0 2
202 5              0.000    3.485  10.158  11.495
 2   0    2 0 0 0
203 5              2.719    3.485  4.720   10.158
 2   0    0 0 0 0
204 5              3 735    4.501  8.113   13.551
 2   0    0 0 0 0
205 5              3.735    4.501  1.338   6.776
 2   0    0 0 0 0
206 5              0.000    3.485  3.388   4.720
 2   0    2 0 0 0
207 5              9 939    10 455 8.113   13.551
 2   0    0 0 0 0
208 5              3.735    10.455 6.776   8.113
 2   0    0 0 0 0
209 5              9 939    10.455 1.338   6.776
 2   0    0 0 0 0
210 5              10.705   11.226 1.338   6.776
 2   0    0 0 0 0
211 5              2.719    3.485 -2.050   3.388
 2   0    0 0 0 0
212 5              3.735    10.455 0.000   1.338
 2   0    0 0 0 0
213 5              10.705   18.750 0.000   1.338
 2   0    0 0 0 0
214 5              3.735    4.501 -5.438   0.000
 2   0    0 0 0 0
215 5              0.000    3.485 -3.382  -2.050
 2   0    2 0 0 0
216 5              2.719    3.485 -8.820  -3.382
 2   0    0 0 0 0
217 5              9.939    10.455 -5.438  0.000
 2   0    0 0 0 0
218 5              10.705   11.226 -5.438  0.000
 2   0    0 0 0 0
219 5              3.735    10.455 -6.775  -5.438
 2   0    0 0 0 0
220 5              0.000    3.485  -10.157 -8.820
 2   0    2 0 0 0
221 5              3.735    4.501  -12.213 -6.775
 2   0    0 0 0 0
222 5              2.719    3.485  -15.595 -10.157
 2   0    0 0 2 0
223 5              9.939    10.455 -12.213 -6.775
 2   0    0 0 0 0
```

```
*
*    SHELL REGIONS
*
301 5            0.000   2.719   19.680   20.180
 1  0   2 2 0 1
302 5            4.501   11.226  16.933   17.433
 1  0   2 2 0 1
303 5            11.226  11 306  13.551   16.933
 1  0   0 1 2 2
304 5            11.306  16.584  13.471   13.551
 1  0   2 2 0 1
305 5            16.584  16.664  8.113    13.471
 1  0   0 1 2 2
306 5            18.750  19.250 -6.775    8.113
 1  0   0 1 2 2
307 5            16.584  16.664 -12.133  -6.775
 1  0   0 1 2 2
308 5            11.306  16.584 -12.213  -12.133
 1  0   2 2 1 0
309 5            11.226  11.306 -15.595  -12.213
 1  0   0 1 2 2
310 5            4 501   11.226 -16.095  -15.595
 1  0   2 2 1 0
311 5            0.000   2.719  -18.320  -17.820
 1  0   2 2 1 0
*
*
*
MATERIALS
*
*    SPECIFIC HEAT AND DENSITY VALUES ARE NOT REQUIRED
*    FOR A STEADY STATE ANALYSIS
*
1 FUEL 0 0 0 -4
2 NSORB 0 0 0 -2
*
*    NSORB ASSUMED TO HAVE THE SAME PROPERTIES AS SS304
*
3 ZIRCALOY  0 0 0 -3
*
*    PROPERTIES OF ZIRCALOY-2 ARE USED FOR ZIRCALOY-4
*
4 ARGON 0 0 0 -1
5 SS304 0 0 0 -2
*
*
INITIAL TEMPERATURES
1 250.0
2 400.0
3 500.0
*
*
HEAT GENERATIONS
1 9.776D-3
*
*
BOUNDARY CONDITIONS
*
*    CONSTANT TEMPERATURE CONDITION ON SHELL
*
1 2 229.0
*
*    INSULATED SURFACE
*
2 0
 0.0 0.0 0.0 0.0 0.0 0
*
*    RADIATION BETWEEN ZIRCALOY AND ZIRCALOY
*
3 3
 0.0 5.005D-14 0.0 0.0 0.0 0
*
*    RADIATION BETWEEN ZIRCALOY AND STEEL
*
4 3
 0.0 6.246D-14 0.0 0.0 0.0 0
*
*    RADIATION BETWEEN STEEL AND GAS
*
5 3
 0.0 1.175D-13 0.0 0.0 0.0 0
*
*    RADIATION BETWEEN STEEL AND STEEL
*
6 3
 0.0 8.308D-14 0.0 0.0 0.0 0
*
*    RADIATION BETWEEN ZIRCALOY AND GAS
*
7 3
 0.0 8.008D-14 0.0 0.0 0.0 0
*
*
XGRID
0.0 2.639 2.719 3.485 3.735 4.501 4.581 9.859 9.939
*10 455 10.705 11.226 11.306 16.584 16.664 18.750 19.250
3 1 1 1 1 1 2 1 1 1 1 1 2 1 1 1
*
```

```
•
YGRID
-18.320 -17.820 -16.095 -15.595 -15.515 -12.213 -12.133
●-10.237 -10.157 -8.820 -8.740 -6.855 -6.775 -5.438 -5.358
●-3.462 -3.382 -2.050 -1.970 -0.080 0.000 1.338 1.418 3.308
●3.388 4.720 4.800 6.696 6.776 8.113 8.193 10.078 10.158
●11.495 11.575 13.471 13.551 16.853 16.933 17.433 19.680 20.180
1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1
●1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1
•
•
ANALYTICAL FUNCTIONS

TABULAR FUNCTIONS
•
•     K OF PURE ARGON, REF: LIENHARD
•
1 6
  100 1.461D-5  200  1.669D-5  300 1.864D-5
● 400 2.049D-5  500 2.224D-5  1000 2.981D-5
•
•     K OF SS304 AND NSORB, REF: ORNL/CSD/TM-149
•
2 17
 100 0.0121  150 0.0125  200 0.0129  250 0.0133
●300 0.0136  350 0.014   400 0.0144  450 0.0147  500 0.0151
●550 0.0154  600 0.0157  650 0.0161  700 0.0164  750 0.0164
●800 0.0169  850 0.0174  900 0.0176
•
•     K OF ZIRCALOY-2, REF: RUST
•
3 5
  100.00 0.009472  200.00 0.009569  400.00 0.009875
● 600.00 0.01024   800.00 0.01061
•
•     K EFFECTIVE OF FUEL REGION, REF: EMAD PG 139
•
4 7
  400.00 2.222D-3  500.00 3.056D-3  600.00 3.611D-3
● 700.00 4.444D-3  800.00 5.278D-3  900.00 6.389D-3
● 1000.0 7.639D-3
•
•
STEADY STATE PARAMETERS
-20 0.001

%
```

HEATING6 Input for Argon Filled Cask During PFE

```
&OPTION MAXBDC=7,NDIMEN=2,MAXGGL=45,MAXPBT=1,MAXPRS=17,
@MAXPTS=950,MAXREG=98,MAXRFG=25,MAXSUR=1000,MAXTFG=50,
@MAXANA=1,MAXHGN=1,MAXMAT=5,
@MAXZFG=1,MWIDTH=250,DIRECT=T,LBOUND=T,&END
 17 ELEM IF-300 BASKET, ARGON, TSHELL 453.7, PFE,FIRST ITERATION
300 7 1 0.0 0.0 0.0 1 0
0 0 0 0 0 0 0 0 200
REGIONS
*
*    FUEL REGIONS
*
1   1           0.000   2.639   11.575   16.853
 3   1   2 0 0 0
2   1           0.000   2.639   4.800    10.078
 3   1   2 0 0 0
3   1           0.000   2.639  -1.970    3.308
 3   1   2 0 0 0
4   1           0.000   2.639  -8.740   -3.462
 3   1   2 0 0 0
5   1           0.000   2.639  -15.515  -10.237
 3   1   2 0 0 0
6   1           4.581   9.859   8.193    13.471
 3   1   0 0 0 0
7   1           4.581   9.859   1.418    6.696
 3   1   0 0 0 0
8   1           4.581   9.859  -5.358   -0.080
 3   1   0 0 0 0
9   1           4.581   9.859  -12.133  -6.855
 3   1   0 0 0 0
10  1           11.306  16.584  1.418    6.696
 3   1   0 0 0 0
11  1           11.306  16.584  -5.358  -0.080
 3   1   0 0 0 0
*
*  POISON REGIONS
*
14  2           3.485   3.735  -15.595   16.933
 2   0   0 0 2 2
15  2           10.455  10.705  -12.213  13.551
 2   0   0 0 2 2
*
*  CHANNEL REGIONS
*
16  3           0.000   2.639   11.495   11.575
 2   0   2 0 0 0
17  3           2.639   2.719   11.495   16.933
 2   0   0 0 0 0
18  3           0.000   2.639   16.853   16.933
 2   0   2 0 0 0
19  3           0.000   2.639   4.720    4.800
 2   0   2 0 0 0
```

20	3					2.639	2.719	4.720	10.158
2	0	0	0	0	0				
21	3					0.000	2.639	10.078	10.158
2	0	2	0	0	0				
22	3					0.000	2.639	-2.050	-1.970
2	0	2	0	0	0				
23	3					2.639	2.719	-2.050	3.388
2	0	0	0	0	0				
24	3					0.000	2.639	3.308	3.388
2	0	2	0	0	0				
25	3					0.000	2.639	-8.820	-8.740
2	0	2	0	0	0				
26	3					2.639	2.719	-8.820	-3.382
2	0	0	0	0	0				
27	3					0.000	2.639	-3.462	-3.382
2	0	2	0	0	0				
28	3					0.000	2.639	-15.595	-15.515
2	0	2	0	0	0				
29	3					2.639	2.719	-15.595	-10.157
2	0	0	0	0	0				
30	3					0.000	2.639	-10.237	-10.157
2	0	2	0	0	0				
31	3					4.501	4.581	8.113	13.551
2	0	0	0	0	0				
32	3					4.581	9.859	8.113	8.193
2	0	0	0	0	0				
33	3					9.859	9.939	8.113	13.551
2	0	0	0	0	0				
34	3					4.581	9.859	13.471	13.551
2	0	0	0	0	0				
35	3					4.501	4.581	1.338	6.776
2	0	0	0	0	0				
36	3					4.581	9.859	1.338	1.418
2	0	0	0	0	0				
37	3					9.859	9.939	1.338	6.776
2	0	0	0	0	0				
38	3					4.581	9.859	6.696	6.776
2	0	0	0	0	0				
39	3					4.501	4.581	-5.438	0.000
2	0	0	0	0	0				
40	3					4.581	9.859	-5.438	-5.358
2	0	0	0	0	0				
41	3					9.859	9.939	-5.438	0.000
2	0	0	0	0	0				
42	3					4.581	9.859	-0.080	0.000
2	0	0	0	0	0				
43	3					4.501	4.581	-12.213	-6.775
2	0	0	0	0	0				
44	3					4.581	9.859	-12.213	-12.133
2	0	0	0	0	0				
45	3					9.859	9.939	-12.213	-6.775
2	0	0	0	0	0				
46	3					4.581	9.859	-6.855	-6.775
2	0	0	0	0	0				

```
47  3            11.226 11.306 1.338    6.776
 2   0   0 0 0 0
48  3            11.306 16.584 1.338    1.418
 2   0   0 0 0 0
49  3            16.584 16.664 1.338    6.776
 2   0   0 0 0 0
50  3            11.306 16.584 6.696    6.776
 2   0   0 0 0 0
51  3            11.226 11.306 -5.438   0.000
 2   0   0 0 0 0
52  3            11.306 16.584 -5.438  -5.358
 2   0   0 0 0 0
53  3            16.584 16.664 -5.438   0.000
 2   0   0 0 0 0
54  3            11.306 16.584 -0.080   0.000
 2   0   0 0 0 0
*
* OUTSIDE GAP REGIONS
*
101 4            0.000  2.719  16.933  19.680
 1   0   2 2 4 4
102 4            3.735  11.226 13.551  16.933
 1   0   6 6 4 4
103 4            10.705 11.306 13.471  13.551
 1   0   6 6 0 0
104 4            10.705 16.584 8.113   13.471
 1   0   6 6 5 5
105 4            10.705 18.750 6.776   8.113
 1   0   6 6 7 7
106 4            16.664 18.750 1.338   6.776
 1   0   4 4 0 0
107 4            16.664 18.750 -5.438  0.000
 1   0   4 4 0 0
108 4            10.705 18.750 -6.775 -5.438
 1   0   6 6 7 7
109 4            10.705 16.584 -12.133 -6.775
 1   0   6 6 5 5
110 4            10.705 11.306 -12.213 -12.133
 1   0   6 6 0 0
111 4            3.735  11.226 -15.595 -12.213
 1   0   6 6 4 4
112 4            0.000  2.719  -17.820 -15.595
 1   0   2 2 4 4
```

```
*
*  INSIDE GAP REGIONS
*
201 4                2.719    3.485  11.495   16.933
 2   0    4 4 0 2
202 4                0.000    3.485  10.158   11.495
 2   0    2 0 3 3
203 4                2.719    3.485  4.720    10.158
 2   0    4 4 0 0
204 4                3.735    4.501  8.113    13.551
 2   0    4 4 0 0
205 4                3.735    4.501  1.338    6.776
 2   0    4 4 0 0
206 4                0.000    3.485  3.388    4.720
 2   0    2 0 3 3
207 4                9.939    10.455 8.113    13.551
 2   0    4 4 0 0
208 4                3.735    10.455 6.776    8.113
 2   0    6 6 3 3
209 4                9.939    10.455 1.338    6.776
 2   0    4 4 0 0
210 4                10.705   11.226 1.338    6.776
 2   0    4 4 0 0
211 4                2.719    3.485 -2.050    3.388
 2   0    4 4 0 0
212 4                3.735    10.455 0.000    1.338
 2   0    6 6 3 3
213 4                10.705   18.750 0.000    1.338
 2   0    6 6 3 3
214 4                3.735    4.501 -5.438    0.000
 2   0    4 4 0 0
215 4                0.000    3.485 -3.382   -2.050
 2   0    2 0 3 3
216 4                2.719    3.485 -8.820   -3.382
 2   0    4 4 0 0
217 4                9.939    10.455 -5.438   0.000
 2   0    4 4 0 0
218 4                10.705   11.226 -5.438   0.000
 2   0    4 4 0 0
219 4                3.735    10.455 -6.775   -5.438
 2   0    6 6 3 3
220 4                0.000    3.485  -10.157 -8.820
 2   0    2 0 3 3
221 4                3.735    4.501  -12.213 -6.775
 2   0    4 4 0 0
222 4                2.719    3.485  -15.595 -10.157
 2   0    4 4 2 0
223 4                9.939    10.455 -12.213 -6.775
 2   0    4 4 0 0
```

```
*
*  SHELL REGIONS
*
301 5               0.000    2.719   19.680    20.180
 1   0   2 2 0 1
302 5               4.501   11.226   16.933    17.433
 1   0   2 2 0 1
303 5              11.226   11.306   13.551    16.933
 1   0   0 1 2 2
304 5              11.306   16.584   13.471    13.551
 1   0   2 2 0 1
305 5              16.584   16.664   8.113     13.471
 1   0   0 1 2 2
306 5              18.750   19.250. -6.775     8.113
 1   0   0 1 2 2
307 5              16.584   16.664 -12.133    -6.775
 1   0   0 1 2 2
308 5              11.306   16.584 -12.213   -12.133
 1   0   2 2 1 0
309 5              11.226   11.306 -15.595   -12.213
 1   0   0 1 2 2
310 5               4.501   11.226 -16.095   -15.595
 1   0   2 2 1 0
311 5               0.000    2.719  -18.320   -17.820
 1   0   2 2 1 0
*
*
*
MATERIALS
*
*  SPECIFIC HEAT AND DENSITY VALUES ARE NOT REQUIRED
*  FOR A STEADY STATE ANALYSIS
*
1 FUEL 0 0 0 -4
2 NSORB 0 0 0 -2
*
*  NSORB ASSUMED TO HAVE THE SAME PROPERTIES AS SS304
*
3 ZIRCALOY  0 0 0 -3
*
*  PROPERTIES OF ZIRCALOY-2 ARE USED FOR ZIRCALOY-4
*
4 ARGON 0 0 0 -1
5 SS304 0 0 0 -2
*
*
INITIAL TEMPERATURES
1 250.0
2 400.0
3 500.0
*
*
HEAT GENERATIONS
1 9.776D-3
```

```
*
*
BOUNDARY CONDITIONS
*
*  CONSTANT TEMPERATURE CONDITION ON SHELL
*
1 2 453.7

*
*  INSULATED SURFACE
*
2 0
 0.0 0.0 0.0 0.0 0.0 0
*
*  RADIATION BETWEEN ZIRCALOY AND ZIRCALOY
*
3 3
 0.0 5.005D-14 0.0 0.0 0.0 0
*
*  RADIATION BETWEEN ZIRCALOY AND STEEL
*
4 3
 0.0 6.246D-14 0.0 0.0 0.0 0
*
*  RADIATION BETWEEN STEEL AND GAS
*
5 3
 0.0 1.175D-13 0.0 0.0 0.0 0
*
*  RADIATION BETWEEN STEEL AND STEEL
*
6 3
 0.0 8.308D-14 0.0 0.0 0.0 0
*
*  RADIATION BETWEEN ZIRCALOY AND GAS
*
7 3
 0.0 8.008D-14 0.0 0.0 0.0 0
*
*
XGRID
0.0 2.639 2.719 3.485 3.735 4.501 4.581 9.859 9.939
@10.455 10.705 11.226 11.306 16.584 16.664 18.750 19.250
3 1 1 1 1 1 2 1 1 1 1 1 2 1 1 1
*
```

```
*
YGRID
-18.320 -17.820 -16.095 -15.595 -15.515 -12.213 -12.133
@-10.237 -10.157 -8.820 -8.740 -6.855 -6.775 -5.438 -5.358
@-3.462 -3.382 -2.050 -1.970 -0.080 0.000 1.338 1.418 3.308
@3.388 4.720 4.800 6.696 6.776 8.113 8.193 10.078 10.158
@11.495 11.575 13.471 13.551 16.853 16.933 17.433 19.680 20.180
1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1
@1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1
*
*
ANALYTICAL FUNCTIONS

TABULAR FUNCTIONS
*
*  K OF PURE ARGON, REF: LIENHARD
*
1 6
  100 1.461D-5  200  1.669D-5  300 1.864D-5
@ 400 2.049D-5  500 2.224D-5  1000 2.981D-5
*
*  K OF SS304 AND NSORB, REF: ORNL/CSD/TM-149
*
2 17
 100 0.0121  150 0.0125  200 0.0129  250 0.0133
@300 0.0136  350 0.014   400 0.0144  450 0.0147  500 0.0151
@550 0.0154  600 0.0157  650 0.0161  700 0.0164  750 0.0164
@800 0.0169  850 0.0174  900 0.0176
*
*  K OF ZIRCALOY-2, REF: RUST
*
3 5
  100.00 0.009472  200.00 0.009569  400.00 0.009875
@ 600.00 0.01024   800.00 0.01061
*
*  K EFFECTIVE OF FUEL REGION, REF: RUN 3
*
4 10
  601.18 0.002636  650.92 0.002137  650.97 0.002136
@655.70 0.002969  656.01 0.002980  721.83 0.004982
@721.84 0.004986  741.77 0.006393  741.85 0.006405
@766.60 0.014849
*
*
STEADY STATE PARAMETERS
-20 0.001
%
END
```

3. Effective Fuel Thermal Conductivities Evaluation

Keff of Fuel During LOMC for Argon Filled Cask

ASSEMBLY 1

T_{max}	566.29 °F		
T_{LEFT}	566.29 °F	T_{avg}	552.66 °F
T_{TOP}	566.29 °F	ΔT	13.63 °F
T_{RIGHT}	562.86 °F	k_{eff}	0.002498 Btu/min·in·°F
T_{BOTTOM}	515.2 °F		

ASSEMBLY 2

T_{max}	661.35 °F		
T_{LEFT}	661.35 °F	T_{avg}	655.3175 °F
T_{TOP}	661.35 °F	ΔT	6.0325 °F
T_{RIGHT}	657.23 °F	k_{eff}	0.005643 Btu/min·in·°F
T_{BOTTOM}	641.34 °F		

ASSEMBLY 3

T_{max}	686.49 °F		
T_{LEFT}	686.49 °F	T_{avg}	683.8525 °F
T_{TOP}	683.97 °F	ΔT	2.6375 °F
T_{RIGHT}	680.96 °F	k_{eff}	0.012907 Btu/min·in·°F
T_{BOTTOM}	683.99 °F		

ASSEMBLY 4

T_{max}	661.22 °F		
T_{LEFT}	661.22 °F	T_{avg}	655.1675 °F
T_{TOP}	641.13 °F	ΔT	6.0525 °F
T_{RIGHT}	657.1 °F	k_{eff}	0.005624 Btu/min·in·°F
T_{BOTTOM}	661.22 °F		

ASSEMBLY 5

T_{max}	565.74 °F		
T_{LEFT}	565.74 °F	T_{avg}	552.0375 °F
T_{TOP}	514.33 °F	ΔT	13.7025 °F
T_{RIGHT}	562.34 °F	k_{eff}	0.002484 Btu/min·in·°F
T_{BOTTOM}	565.74 °F		

ASSEMBLY 6

T_{max}	561.66 °F		
T_{LEFT}	561.66 °F	T_{avg}	542.8875 °F
T_{TOP}	561.66 °F	ΔT	18.7725 °F
T_{RIGHT}	540.85 °F	k_{eff}	0.001813 Btu/min·in·°F
T_{BOTTOM}	507.38 °F		

ASSEMBLY 7

T_{max}	637.18 °F		
T_{LEFT}	637.18 °F	T_{avg}	629.21 °F
T_{TOP}	637.18 °F	ΔT	7.97 °F
T_{RIGHT}	619.27 °F	k_{eff}	0.004271 Btu/min·in·°F
T_{BOTTOM}	623.21 °F		

ASSEMBLY 8

T_{max}	637.16 °F		
T_{LEFT}	637.16 °F	T_{avg}	629.185 °F
T_{TOP}	623.17 °F	ΔT	7.975 °F
T_{RIGHT}	619.25 °F	k_{eff}	0.004269 Btu/min· in· °F
T_{BOTTOM}	637.16 °F		

ASSEMBLY 9

T_{max}	561.57 °F		
T_{LEFT}	561.57 °F	T_{avg}	542.8025 °F
T_{TOP}	507.28 °F	ΔT	18.7675 °F
T_{RIGHT}	540.79 °F	k_{eff}	0.001814 Btu/min· in· °F
T_{BOTTOM}	561.57 °F		

ASSEMBLY 10

T_{max}	489.46 °F		
T_{LEFT}	489.46 °F	T_{avg}	473.6325 °F
T_{TOP}	489.46 °F	ΔT	15.8275 °F
T_{RIGHT}	451.54 °F	k_{eff}	0.002151 Btu/min· in· °F
T_{BOTTOM}	464.07 °F		

ASSEMBLY 11

T_{max}	489.46 °F		
T_{LEFT}	489.46 °F	T_{avg}	473.63 °F
T_{TOP}	464.06 °F	ΔT	15.83 °F
T_{RIGHT}	451.54 °F	k_{eff}	0.00215 Btu/min· in· °F
T_{BOTTOM}	489.46 °F		

EFFECTIVE CONDUCTIVITIES

ASSY	T	K
11	473.63	0.002150
10	473.63	0.002151
9	542.80	0.001814
6	542.89	0.001813
5	552.04	0.002484
1	552.66	0.002498
8	629.19	0.004269
7	629.21	0.004271
4	655.17	0.005624
2	655.32	0.005643
3	683.85	0.012907

Keff of Fuel During PFE for Argon Filled Cask

ASSEMBLY 1

T_{max}	667.43 °F		
T_{LEFT}	667.43 °F	T_{avg}	656.0075 °F
T_{TOP}	667.43 °F	ΔT	11.4225 °F
T_{RIGHT}	664.76 °F	k_{eff}	0.00298 Btu/min· in· °F
T_{BOTTOM}	624.41 °F		

ASSEMBLY 2

T_{max}	747.16 °F		
T_{LEFT}	747.16 °F	T_{avg}	741.845 °F
T_{TOP}	747.16 °F	ΔT	5.315 °F
T_{RIGHT}	743.8 °F	k_{eff}	0.006405 Btu/min· in· °F
T_{BOTTOM}	729.26 °F		

ASSEMBLY 3

T_{max}	768.89 °F		
T_{LEFT}	768.89 °F	T_{avg}	766.5975 °F
T_{TOP}	766.66 °F	ΔT	2.2925 °F
T_{RIGHT}	764.17 °F	k_{eff}	0.014849 Btu/min· in· °F
T_{BOTTOM}	766.67 °F		

ASSEMBLY 4

T_{max}	747.09 °F		
T_{LEFT}	747.09 °F	T_{avg}	741.765 °F
T_{TOP}	729.15 °F	ΔT	5.325 °F
T_{RIGHT}	743.73 °F	k_{eff}	0.006393 Btu/min· in· °F
T_{BOTTOM}	747.09 °F		

ASSEMBLY 5

T_{max}	667.16 °F		
T_{LEFT}	667.16 °F	T_{avg}	655.695 °F
T_{TOP}	623.96 °F	ΔT	11.465 °F
T_{RIGHT}	664.5 °F	k_{eff}	0.002969 Btu/min· in· °F
T_{BOTTOM}	667.16 °F		

ASSEMBLY 6

T_{max}	666.9 °F		
T_{LEFT}	666.9 °F	T_{avg}	650.965 °F
T_{TOP}	666.9 °F	ΔT	15.935 °F
T_{RIGHT}	649.39 °F	k_{eff}	0.002136 Btu/min· in· °F
T_{BOTTOM}	620.67 °F		

ASSEMBLY 7

T_{max}	728.67 °F		
T_{LEFT}	728.67 °F	T_{avg}	721.8425 °F
T_{TOP}	728.67 °F	ΔT	6.8275 °F
T_{RIGHT}	713.64 °F	k_{eff}	0.004986 Btu/min· in· °F
T_{BOTTOM}	716.39 °F		

ASSEMBLY 8

T_{max}	728.66 °F		
T_{LEFT}	728.66 °F	T_{avg}	721.8275 °F
T_{TOP}	716.36 °F	ΔT	6.8325 °F
T_{RIGHT}	713.63 °F	k_{eff}	0.004982 Btu/min·in·°F
T_{BOTTOM}	728.66 °F		

ASSEMBLY 9

T_{max}	666.85 °F		
T_{LEFT}	666.85 °F	T_{avg}	650.92 °F
T_{TOP}	620.62 °F	ΔT	15.93 °F
T_{RIGHT}	649.36 °F	k_{eff}	0.002137 Btu/min·in·°F
T_{BOTTOM}	666.85 °F		

ASSEMBLY 10

T_{max}	614.1 °F		
T_{LEFT}	614.1 °F	T_{avg}	601.1825 °F
T_{TOP}	614.1 °F	ΔT	12.9175 °F
T_{RIGHT}	583.42 °F	k_{eff}	0.002635 Btu/min·in·°F
T_{BOTTOM}	593.11 °F		

ASSEMBLY 11

T_{max}	614.09 °F		
T_{LEFT}	614.09 °F	T_{avg}	601.1775 °F
T_{TOP}	593.11 °F	ΔT	12.9125 °F
T_{RIGHT}	583.42 °F	k_{eff}	0.002636 Btu/min·in·°F
T_{BOTTOM}	614.09 °F		

EFFECTIVE CONDUCTIVITIES

ASSY	T	K
11	601.18	0.002636
10	601.18	0.002635
9	650.92	0.002137
6	650.97	0.002136
5	655.70	0.002969
1	656.01	0.002980
8	721.83	0.004982
7	721.84	0.004986
4	741.77	0.006393
2	741.85	0.006405
3	766.60	0.014849

4. HEATING6 Output - Basket Spacer Disk Temperature Distribution During Normal Condition of Transport

Temperature Distribution of Argon Filled Cask During LONC

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73	4.50	4.58	7.22	9.86	9.94	10.45
-18.32	229.00	229.00	229.00	229.00	229.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-17.82	230.64	230.63	230.62	230.61	230.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-16.09	450.71	450.42	449.69	449.08	449.07	0.00	0.00	229.00	229.00	229.00	229.00	229.00	229.00
-15.59	507.68	507.20	505.93	504.55	504.48	453.57	453.23	231.51	231.10	230.54	230.33	230.28	229.86
-15.51	508.03	507.54	506.27	504.88	504.83	453.59	453.14	260.44	247.98	237.85	235.10	234.84	232.84
-13.86	541.03	539.86	536.30	530.12	529.99	465.00	464.50	420.64	416.77	375.94	330.67	326.38	293.64
-12.21	561.81	561.05	558.63	554.07	553.93	495.85	495.36	501.85	503.34	499.47	482.87	481.56	401.16
-12.13	562.61	561.85	559.44	554.96	554.83	497.84	497.66	503.69	503.71	499.79	483.20	483.04	401.44
-10.24	577.44	576.90	575.34	572.95	572.88	539.80	539.72	541.04	541.05	535.14	512.11	511.92	415.68
-10.16	577.58	577.04	575.48	573.15	573.62	541.33	541.29	542.46	542.48	536.48	513.21	513.02	416.47
-8.82	648.06	647.37	645.24	641.36	640.41	566.02	565.96	559.57	559.57	554.66	530.09	529.89	431.75
-8.74	648.21	647.52	645.39	641.54	641.33	567.57	567.38	560.40	560.39	555.40	531.03	530.83	432.82
-6.85	655.03	654.50	652.86	650.08	649.92	591.78	591.54	574.66	574.61	568.44	550.47	550.26	463.15
-6.77	655.28	654.76	653.14	650.39	650.24	592.59	592.18	575.31	574.74	568.55	550.60	550.53	464.95
-5.44	658.79	658.41	657.26	655.19	655.05	608.79	608.42	629.10	629.69	627.47	612.09	611.13	494.64
-5.36	658.95	658.59	657.45	655.43	655.30	609.94	609.82	629.75	629.82	627.59	612.22	611.93	496.39
-3.46	661.82	661.57	660.82	659.65	659.57	629.10	629.04	636.65	636.67	633.89	620.04	619.81	527.21
-3.38	661.87	661.62	660.87	659.72	659.81	629.61	629.60	636.87	636.89	634.09	620.30	620.06	528.10
-2.05	684.01	683.79	683.12	681.94	681.49	637.20	637.17	639.78	639.79	636.70	623.70	623.48	538.39
-1.97	684.06	683.84	683.17	682.02	681.88	637.66	637.55	639.91	639.92	636.81	623.85	623.63	538.76
-0.08	684.81	684.61	684.00	683.01	682.88	639.45	639.29	641.14	641.15	637.89	625.35	625.12	539.75
0.00	684.82	684.62	684.02	683.03	682.90	639.26	638.94	641.14	641.14	637.89	625.35	624.98	539.59
0.67	684.88	684.68	684.07	683.08	682.95	638.16	637.73	640.42	640.59	637.18	611.37	603.74	538.32
1.34	684.83	684.62	684.02	683.03	682.90	639.27	638.95	641.15	641.16	637.90	625.36	625.00	539.59
1.42	684.81	684.61	684.00	683.01	682.88	639.45	639.30	641.15	641.16	637.91	625.36	625.14	539.76
3.31	684.07	683.85	683.18	682.03	681.88	637.69	637.58	639.93	639.94	636.83	623.87	623.65	538.70
3.39	684.01	683.79	683.12	681.95	681.50	637.23	637.20	639.80	639.81	636.72	623.72	623.50	538.40
4.72	661.95	661.69	660.95	659.80	659.89	629.66	629.65	636.90	636.92	634.11	620.32	620.08	528.12
4.80	661.90	661.64	660.90	659.73	659.65	629.15	629.10	636.68	636.70	633.91	620.06	619.83	527.23
6.70	659.05	658.68	657.55	655.53	655.41	610.03	609.90	629.78	629.85	627.62	612.25	611.95	496.42
6.78	658.88	658.51	657.36	655.29	655.16	608.87	608.51	629.13	629.72	627.49	612.12	611.15	494.66
8.11	655.40	654.88	653.26	650.52	650.36	592.70	592.29	575.37	574.79	568.59	550.65	550.58	464.98
8.19	655.15	654.62	652.99	650.20	650.04	591.89	591.65	574.72	574.67	568.48	550.52	550.31	463.18
10.08	648.36	647.67	645.54	641.70	641.49	567.73	567.54	560.46	560.46	555.45	531.09	530.89	432.85
10.16	648.21	647.52	645.39	641.51	640.57	566.18	566.12	559.64	559.64	554.70	530.15	529.95	431.78
11.49	577.94	577.40	575.84	573.51	573.98	541.54	541.50	542.57	542.59	536.57	513.26	513.08	416.50
11.57	577.80	577.26	575.70	573.31	573.24	540.00	539.93	541.15	541.16	535.22	512.16	511.97	415.71
13.47	563.06	562.29	559.88	555.42	555.30	498.11	497.93	503.78	503.80	499.86	483.24	483.09	401.47
13.55	562.27	561.49	559.08	554.54	554.41	496.13	495.64	501.95	503.43	499.53	482.92	481.61	401.19
15.20	541.92	540.76	537.16	530.88	530.75	465.33	464.83	420.83	416.95	375.99	330.70	326.40	293.65
16.85	509.00	508.51	507.21	505.77	505.71	453.94	453.49	260.49	248.00	237.85	235.11	234.84	232.84
16.93	508.66	508.17	506.87	505.44	505.36	453.92	453.58	231.51	231.10	230.54	230.33	230.28	229.86
17.43	462.41	462.11	461.40	460.82	460.81	0.00	0.00	229.00	229.00	229.00	229.00	229.00	229.00
19.68	230.63	230.62	230.61	230.60	230.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.18	229.00	229.00	229.00	229.00	229.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75	19.25
-18.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-17.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-16.09	229.00	229.00	0.00	0.00	0.00	0.00	0.00	0.00
-15.59	229.71	229.29	229.00	0.00	0.00	0.00	0.00	0.00
-15.51	231.78	229.24	229.00	0.00	0.00	0.00	0.00	0.00
-13.86	275.42	229.26	229.00	0.00	0.00	0.00	0.00	0.00
-12.21	400.42	229.37	229.00	229.00	229.00	0.00	0.00	0.00
-12.13	401.00	272.03	229.23	229.14	229.07	229.00	0.00	0.00
-10.24	415.21	374.83	368.95	283.49	229.18	229.00	0.00	0.00
-10.16	415.99	377.48	371.97	285.30	229.19	229.00	0.00	0.00
-8.82	431.24	400.57	396.16	310.30	229.21	229.00	0.00	0.00
-8.74	432.31	401.07	396.59	311.68	229.21	229.00	0.00	0.00
-6.85	462.54	383.05	372.13	341.24	229.38	229.00	0.00	0.00
-6.77	464.19	376.48	363.78	343.32	232.35	229.00	230.57	229.00
-5.44	493.94	466.88	467.27	449.58	411.75	408.42	230.44	229.00
-5.36	495.98	467.55	467.49	449.77	412.06	411.77	230.23	229.00
-3.46	526.88	487.34	487.26	469.16	436.01	435.78	230.07	229.00
-3.38	527.77	487.99	487.91	469.79	436.76	436.53	230.08	229.00
-2.05	538.07	496.51	496.42	478.08	446.25	446.00	230.15	229.00
-1.97	538.44	496.86	496.78	478.43	446.68	446.43	230.15	229.00
-0.08	539.38	499.98	499.89	482.14	452.41	452.14	230.50	229.00
0.00	538.92	500.04	499.88	482.13	452.42	452.06	230.71	229.00
0.67	537.47	509.01	505.55	481.80	446.77	442.94	231.21	229.00
1.34	538.92	500.04	499.89	482.14	452.42	452.07	230.71	229.00
1.42	539.38	499.98	499.90	482.14	452.41	452.15	230.50	229.00
3.31	538.45	496.87	496.79	478.44	446.69	446.44	230.15	229.00
3.39	538.08	496.51	496.43	478.08	446.25	446.01	230.15	229.00
4.72	527.79	488.00	487.92	469.79	436.77	436.53	230.08	229.00
4.80	526.89	487.35	487.27	469.16	436.01	435.78	230.07	229.00
6.70	496.01	467.56	467.49	449.78	412.06	411.77	230.23	229.00
6.78	493.97	466.89	467.27	449.58	411.75	408.42	230.44	229.00
8.11	464.22	376.49	363.79	343.32	232.35	229.00	230.57	229.00
8.19	462.58	383.07	372.14	341.24	229.38	229.00	0.00	0.00
10.08	432.34	401.10	396.62	311.68	229.21	229.00	0.00	0.00
10.16	431.27	400.60	396.19	310.30	229.21	229.00	0.00	0.00
11.49	416.03	377.50	372.00	285.31	229.19	229.00	0.00	0.00
11.57	415.24	374.85	368.97	283.50	229.18	229.00	0.00	0.00
13.47	401.03	272.03	229.23	229.14	229.07	229.00	0.00	0.00
13.55	400.45	229.37	229.00	229.00	229.00	0.00	0.00	0.00
15.20	275.43	229.27	229.00	0.00	0.00	0.00	0.00	0.00
16.85	231.78	229.24	229.00	0.00	0.00	0.00	0.00	0.00
16.93	229.71	229.29	229.00	0.00	0.00	0.00	0.00	0.00
17.43	229.00	229.00	0.00	0.00	0.00	0.00	0.00	0.00
19.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Temperature Distribution of Argon Replaced by Steel Case During LOMC

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73	4.50	4.58	7.22	9.86	9.94	10.45
-18.32	229.00	229.00	229.00	229.00	229.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-17.82	230.37	230.38	230.41	230.45	230.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-16.09	235.04	235.08	235.25	235.58	235.58	0.00	0.00	229.00	229.00	229.00	229.00	229.00	229.00
-15.59	236.32	236.35	236.55	237.44	237.65	237.69	237.14	233.50	232.99	230.64	229.57	229.54	229.34
-15.51	236.60	236.62	236.80	237.74	237.83	237.71	237.16	233.88	233.54	230.89	229.67	229.63	229.40
-13.86	252.28	251.59	249.37	245.09	244.94	243.76	243.28	241.54	241.36	235.90	231.54	231.41	230.53
-12.21	262.77	261.98	259.14	253.50	253.32	251.83	251.24	249.06	248.76	240.46	233.47	233.29	232.09
-12.13	263.12	262.35	259.60	253.95	253.77	252.28	251.69	249.57	249.21	240.75	233.57	233.41	232.27
-10.24	271.11	270.60	268.99	265.84	265.61	264.25	263.96	263.51	263.53	258.21	241.12	240.87	239.68
-10.16	271.16	270.65	269.07	266.26	266.03	264.67	264.38	263.96	263.95	258.79	241.45	241.19	239.99
-8.82	272.91	272.56	271.64	270.64	270.61	270.36	270.32	270.43	270.49	265.50	246.86	246.59	245.25
-8.74	273.13	272.78	271.86	270.88	270.88	270.67	270.65	270.77	270.82	265.85	247.21	246.93	245.57
-6.85	283.46	282.96	281.38	278.40	278.26	277.55	277.40	277.20	277.23	271.39	256.17	255.68	253.45
-6.77	283.76	283.26	281.66	278.66	278.52	277.79	277.63	277.35	277.33	271.42	256.45	256.03	253.74
-5.44	287.57	287.07	285.46	282.41	282.25	281.26	280.94	279.91	279.75	272.92	259.47	259.23	257.80
-5.36	287.74	287.24	285.64	282.62	282.46	281.47	281.15	280.14	279.99	273.12	259.60	259.40	258.08
-3.46	290.05	289.75	288.84	287.22	287.08	286.32	286.16	285.94	285.96	282.03	267.73	267.52	266.66
-3.38	290.05	289.76	288.86	287.36	287.24	286.47	286.31	286.11	286.13	282.26	268.03	267.80	266.94
-2.05	290.80	290.55	289.82	288.79	288.72	288.25	288.16	288.09	288.11	284.70	271.69	271.47	270.61
-1.97	290.92	290.66	289.93	288.85	288.78	288.33	288.24	288.17	288.19	284.77	271.85	271.63	270.76
-0.08	293.78	293.42	292.28	290.23	290.11	289.38	289.18	288.72	288.68	284.19	273.71	273.44	272.22
0.00	293.83	293.46	292.32	290.26	290.13	289.39	289.19	288.70	288.63	284.13	273.76	273.52	272.24
0.67	294.03	293.65	292.47	290.35	290.22	289.45	289.23	288.60	288.52	283.96	273.91	273.68	272.30
1.34	293.84	293.47	292.32	290.26	290.14	289.40	289.20	288.70	288.64	284.13	273.76	273.52	272.24
1.42	293.79	293.42	292.28	290.24	290.12	289.38	289.19	288.73	288.68	284.20	273.71	273.44	272.22
3.31	290.94	290.69	289.96	288.88	288.81	288.36	288.27	288.19	288.21	284.78	271.86	271.64	270.77
3.39	290.83	290.58	289.85	288.81	288.75	288.28	288.19	288.11	288.13	284.71	271.70	271.48	270.61
4.72	290.09	289.79	288.90	287.40	287.28	286.51	286.35	286.15	286.16	282.28	268.04	267.82	266.96
4.80	290.09	289.79	288.88	287.26	287.12	286.36	286.20	285.98	285.99	282.06	267.74	267.54	266.68
6.70	287.80	287.30	285.71	282.68	282.53	281.54	281.22	280.21	280.05	273.17	259.62	259.41	258.10
6.78	287.64	287.13	285.52	282.47	282.32	281.33	281.01	279.97	279.82	272.97	259.49	259.25	257.82
8.11	283.85	283.34	281.75	278.75	278.61	277.88	277.71	277.43	277.40	271.47	256.47	256.05	253.75
8.19	283.55	283.05	281.47	278.49	278.35	277.64	277.48	277.27	277.31	271.44	256.19	255.70	253.46
10.08	273.29	272.94	272.01	271.02	271.02	270.80	270.78	270.89	270.94	265.92	247.23	246.95	245.59
10.16	273.07	272.72	271.79	270.78	270.75	270.49	270.45	270.55	270.61	265.56	246.88	246.61	245.26
11.49	271.33	270.82	269.25	266.42	266.19	264.82	264.53	264.11	264.10	258.88	241.46	241.21	240.01
11.57	271.28	270.77	269.16	266.01	265.77	264.41	264.11	263.66	263.68	258.31	241.14	240.89	239.69
13.47	263.39	262.60	259.86	254.16	253.98	252.47	251.88	249.74	249.38	240.82	233.59	233.42	232.28
13.55	263.05	262.25	259.41	253.72	253.53	252.03	251.43	249.23	248.93	240.54	233.49	233.31	232.10
15.20	252.83	252.12	249.82	245.40	245.25	244.02	243.52	241.71	241.53	235.96	231.56	231.42	230.54
16.85	237.60	237.60	237.68	238.35	238.41	238.07	237.45	233.99	233.64	230.91	229.67	229.63	229.40
16.93	237.33	237.34	237.44	238.08	238.26	238.05	237.44	233.60	233.08	230.65	229.58	229.55	229.34
17.43	236.09	236.11	236.22	236.43	236.43	0.00	0.00	229.00	229.00	229.00	229.00	229.00	229.00
19.68	230.30	230.30	230.32	230.33	230.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.18	229.00	229.00	229.00	229.00	229.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75	19.25
-18.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-17.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-16.09	229.00	229.00	0.00	0.00	0.00	0.00	0.00	0.00
-15.59	229.25	229.06	229.00	0.00	0.00	0.00	0.00	0.00
-15.51	229.28	229.04	229.00	0.00	0.00	0.00	0.00	0.00
-13.86	230.09	229.15	229.00	0.00	0.00	0.00	0.00	0.00
-12.21	231.36	229.42	229.00	229.00	229.00	0.00	0.00	0.00
-12.13	231.56	229.79	229.53	229.17	229.01	229.00	0.00	0.00
-10.24	239.10	237.89	237.72	233.21	229.12	229.00	0.00	0.00
-10.16	239.41	238.21	238.03	233.37	229.13	229.00	0.00	0.00
-8.82	244.58	243.18	242.97	236.08	229.21	229.00	0.00	0.00
-8.74	244.90	243.48	243.26	236.24	229.22	229.00	0.00	0.00
-6.85	252.42	250.35	250.04	240.02	229.41	229.00	0.00	0.00
-6.77	252.70	250.63	250.32	240.19	229.48	229.00	229.20	229.00
-5.44	257.03	255.24	254.90	243.03	232.01	231.84	229.55	229.00
-5.36	257.35	255.66	255.30	243.25	232.10	231.96	229.57	229.00
-3.46	266.34	265.91	265.87	255.56	234.96	234.69	230.08	229.00
-3.38	266.63	266.22	266.18	255.90	235.06	234.78	230.10	229.00
-2.05	270.30	269.91	269.88	259.45	236.44	236.14	230.38	229.00
-1.97	270.45	270.05	270.01	259.55	236.53	236.23	230.39	229.00
-0.08	271.67	270.64	270.46	258.12	238.64	238.24	230.74	229.00
0.00	271.68	270.56	270.35	258.04	238.75	238.32	230.75	229.00
0.67	271.66	270.31	270.07	257.84	239.06	238.64	230.78	229.00
1.34	271.68	270.56	270.35	258.04	238.75	238.32	230.75	229.00
1.42	271.67	270.64	270.46	258.12	238.64	238.24	230.74	229.00
3.31	270.46	270.06	270.02	259.56	236.53	236.23	230.39	229.00
3.39	270.31	269.92	269.89	259.46	236.45	236.14	230.38	229.00
4.72	266.64	266.23	266.19	255.91	235.06	234.78	230.10	229.00
4.80	266.36	265.92	265.88	255.57	234.96	234.69	230.08	229.00
6.70	257.37	255.68	255.31	243.26	232.10	231.96	229.57	229.00
6.78	257.05	255.25	254.92	243.04	232.01	231.84	229.55	229.00
8.11	252.72	250.65	250.33	240.19	229.48	229.00	229.20	229.00
8.19	252.43	250.37	250.05	240.03	229.41	229.00	0.00	0.00
10.08	244.91	243.49	243.27	236.24	229.22	229.00	0.00	0.00
10.16	244.60	243.20	242.98	236.08	229.21	229.00	0.00	0.00
11.49	239.42	238.22	238.04	233.38	229.13	229.00	0.00	0.00
11.57	239.11	237.90	237.73	233.21	229.12	229.00	0.00	0.00
13.47	231.57	229.79	229.53	229.17	229.01	229.00	0.00	0.00
13.55	231.37	229.42	229.00	229.00	229.00	0.00	0.00	0.00
15.20	230.10	229.15	229.00	0.00	0.00	0.00	0.00	0.00
16.85	229.29	229.04	229.00	0.00	0.00	0.00	0.00	0.00
16.93	229.25	229.06	229.00	0.00	0.00	0.00	0.00	0.00
17.43	229.00	229.00	0.00	0.00	0.00	0.00	0.00	0.00
19.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Spacer Disk Temperature Distribution for LOMC

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73	4.50	4.58	7.22	9.86	9.94	10.45
-18.32													
-17.82	230.51	230.51	230.52	230.53	230.53								
-16.09	342.88	342.75	342.47	342.33	342.33								
-15.59	372.00	371.78	371.24	371.00	371.07	345.63	345.19	232.51	232.05	230.59	229.95	229.91	229.60
-15.51					371.33	345.65	345.15	247.16	240.76	234.37	232.39	232.24	231.12
-13.86					387.47	354.38	353.89	331.09	329.07	305.92	281.11	278.90	262.09
-12.21					403.63	373.84	373.30	375.46	376.05	369.97	358.17	357.43	316.63
-12.13					404.30	375.06	374.68	376.63				358.23	316.86
-10.24					419.25	402.03	401.84	402.28				376.40	327.68
-10.16	424.37	423.84	422.28	419.71	419.83	403.00	402.84	403.21				377.11	328.23
-8.82	460.49	459.97	458.44	456.00	455.51	418.19	418.14	415.00				388.24	338.50
-8.74					456.11	419.12	419.02	415.59				388.88	339.20
-6.85					464.09	434.67	434.47	425.93				402.97	358.30
-6.77					464.38	435.19	434.91	426.33	426.03	419.99	403.53	403.28	359.35
-5.44					468.65	445.03	444.68	454.51	454.72	450.20	435.78	435.18	376.22
-5.36					468.88	445.71	445.49	454.95				435.66	377.24
-3.46					473.33	457.71	457.60	461.30				443.66	396.94
-3.38	475.96	475.69	474.87	473.54	473.53	458.04	457.96	461.49				443.93	397.52
-2.05	487.41	487.17	486.47	485.37	485.11	462.73	462.66	463.94				447.47	404.50
-1.97					485.33	463.00	462.90	464.04				447.63	404.76
-0.08					486.50	464.42	464.24	464.93				449.28	405.99
0.00					486.52	464.33	464.07	464.92	464.89	461.01	449.56	449.25	405.92
0.67					486.59	463.81	463.48	464.51	464.56	460.57	442.64	438.71	405.31
1.34					486.52	464.34	464.08	464.93	464.90	461.02	449.56	449.26	405.92
1.42					486.50	464.42	464.25	464.94				449.29	405.99
3.31					485.35	463.03	462.93	464.06				447.65	404.78
3.39	487.42	487.19	486.49	485.38	485.13	462.76	462.70	463.96				447.49	404.51
4.72	476.02	475.74	474.93	473.60	473.59	458.09	458.00	461.53				443.95	397.54
4.80					473.39	457.76	457.65	461.33				443.69	396.96
6.70					468.97	445.79	445.56	455.00				435.68	377.26
6.78					468.74	445.10	444.76	454.55	454.77	450.23	435.81	435.20	376.24
8.11					464.49	435.29	435.00	426.40	426.09	420.03	403.56	403.32	359.37
8.19					464.20	434.77	434.57	426.00				403.01	358.32
10.08					456.26	419.27	419.16	415.68				388.92	339.22
10.16	460.64	460.12	458.59	456.15	455.66	418.34	418.29	415.10				388.28	338.52
11.49	424.64	424.11	422.55	419.97	420.09	403.18	403.02	403.34				377.15	328.26
11.57					419.51	402.21	402.02	402.41				376.43	327.70
13.47					404.64	375.29	374.91	376.76				358.26	316.88
13.55					403.97	374.08	373.54	375.59	376.18	370.04	358.21	357.46	316.65
15.20					388.00	354.68	354.18	331.27	329.24	305.98	281.13	278.91	262.10
16.85					372.06	346.01	345.47	247.24	240.82	234.38	232.39	232.24	231.12
16.93	373.00	372.76	372.16	371.76	371.81	345.99	345.51	232.56	232.09	230.60	229.96	229.92	229.60
17.43	349.25	349.11	348.81	348.63	348.62								
19.68	230.47	230.46	230.47	230.47	230.47								
20.18													

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75	19.25
-18.32								
-17.82								
-16.09								
-15.59	229.48	229.17						
-15.51	230.53	229.14						
-13.86	252.76	229.20						
-12.21	315.89	229.39						
-12.13	316.28	250.91	229.38	229.16	229.04			
-10.24	327.16	306.36	303.34	258.35	229.15			
-10.16	327.70	307.85	305.00	259.34	229.16			
-8.82	337.91	321.88	319.57	273.19	229.21			
-8.74	338.61	322.28	319.92	273.96	229.22			
-6.85	357.48	316.70	311.09	290.63	229.40			
-6.77	358.45	313.56	307.05	291.76	230.92	229.00	229.89	
-5.44	375.49	361.06	361.09	346.31	321.88	320.13	230.00	
-5.36	376.67	361.61				321.87	229.90	
-3.46	396.61	376.63				335.24	230.08	
-3.38	397.20	377.11				335.66	230.09	
-2.05	404.19	383.21				341.07	230.27	
-1.97	404.45	383.46				341.33	230.27	
-0.08	405.53	385.31				345.19	230.62	
0.00	405.30	385.30	385.12	370.09	345.59	345.19	230.73	
0.67	404.57	389.66	387.81	369.82	342.91	340.79	231.00	
1.34	405.30	385.30	385.12	370.09	345.59	345.20	230.73	
1.42	405.53	385.31				345.20	230.62	
3.31	404.46	383.47				341.34	230.27	
3.39	404.20	383.22				341.08	230.27	
4.72	397.22	377.12				335.66	230.09	
4.80	396.63	376.64				335.24	230.08	
6.70	376.69	361.62				321.87	229.90	
6.78	375.51	361.07	361.10	346.31	321.88	320.13	230.00	
8.11	358.47	313.57	307.06	291.76	230.92	229.00	229.89	
8.19	357.51	316.72	311.10	290.64	229.40			
10.08	338.63	322.30	319.95	273.96	229.22			
10.16	337.94	321.90	319.59	273.19	229.21			
11.49	327.73	307.86	305.02	259.35	229.16			
11.57	327.17	306.38	303.35	258.36	229.15			
13.47	316.30	250.91	229.38	229.16	229.04			
13.55	315.91	229.39						
15.20	252.77	229.21						
16.85	230.54	229.14						
16.93	229.48	229.17						
17.43								
19.68								
20.18								

5. HEATING6 Output - Average Argon Temperature During Normal Conditions of Transport

Temperature Distribution of Argon in the Cask for LOMC

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73	4.50	4.58	7.22	9.86	9.94	10.45
19.25													
-18.32													
-17.82	230.64	230.63	230.62	230.61	230.61								
-16.09	450.71	450.42	449.69	449.08	449.07								
-15.59	507.68	507.20	505.93	504.55	504.48	453.57	453.23	231.51	231.10	230.54	230.33	230.28	229.86
-15.51					504.83	453.59	453.14	260.44	247.98	237.85	235.10	234.84	232.84
-13.86					529.99	465.00	464.50	420.64	416.77	375.94	330.67	326.38	293.64
-12.21					553.93	495.85	495.36	501.85	503.34	499.47	482.87	481.56	401.16
-12.13					554.83	497.84	497.66	503.69				483.04	401.44
-10.24					572.88	539.80	539.72	541.04				511.92	415.68
-10.16	577.58	577.04	575.48	573.15	573.62	541.33	541.29	542.46				513.02	416.47
-8.82	648.06	647.37	645.24	641.36	640.41	566.02	565.96	559.57				529.89	431.75
-8.74					641.33	567.57	567.38	560.40				530.83	432.82
-6.85					649.92	591.78	591.54	574.66				550.26	463.15
-6.77					650.24	592.59	592.18	575.31	574.74	568.55	550.60	550.53	464.95
-5.44					655.05	608.79	608.42	629.10	629.69	627.47	612.09	611.13	494.64
-5.36					655.30	609.94	609.82	629.75				611.93	496.39
-3.46					659.57	629.10	629.04	636.65				619.81	527.21
-3.38	661.87	661.62	660.87	659.72	659.81	629.61	629.60	636.87				620.06	528.10
-2.05	684.01	683.79	683.12	681.94	681.49	637.20	637.17	639.78				623.48	538.39
-1.97					681.88	637.66	637.55	639.91				623.63	538.76
-0.08					682.88	639.45	639.29	641.14				625.12	539.75
0.00					682.90	639.26	638.94	641.14	641.14	637.89	625.35	624.98	539.59
0.67					682.95	638.16	637.73	640.42	640.59	637.18	611.37	603.74	538.32
1.34					682.90	639.27	638.95	641.15	641.16	637.90	625.36	625.00	539.59
1.42					682.88	639.45	639.30	641.15				625.14	539.76
3.31					681.88	637.69	637.58	639.93				623.65	538.78
3.39	684.01	683.79	683.12	681.95	681.50	637.23	637.20	639.80				623.50	538.40
4.72	661.95	661.69	660.95	659.80	659.89	629.66	629.65	636.90				620.08	528.12
4.80					659.65	629.15	629.10	636.68				619.83	527.23
6.70					655.41	610.03	609.90	629.78				611.95	496.42
6.78					655.16	608.87	608.51	629.13	629.72	627.49	612.12	611.15	494.66
8.11					650.36	592.70	592.29	575.37	574.79	568.59	550.65	550.58	464.98
8.19					650.04	591.89	591.65	574.72				550.31	463.18
10.08					641.49	567.73	567.54	560.46				530.89	432.85
10.16	648.21	647.52	645.39	641.51	640.57	566.18	566.12	559.64				529.95	431.78
11.49	577.94	577.40	575.84	573.51	573.98	541.54	541.50	542.57				513.08	416.50
11.57					573.24	540.00	539.93	541.15				511.97	415.71
13.47					555.30	498.11	497.93	503.78				483.09	401.47
13.55					554.41	496.13	495.64	501.95	503.43	499.53	482.92	481.61	401.19
15.20					530.75	465.33	464.83	420.83	416.95	375.99	330.70	326.40	293.65
16.85					505.71	453.94	453.49	260.49	248.00	237.85	235.11	234.84	232.84
16.93	508.66	508.17	506.87	505.44	505.36	453.92	453.58	231.51	231.10	230.54	230.33	230.28	229.86
17.43	462.41	462.11	461.40	460.82	460.81								
19.68	230.63	230.62	230.61	230.60	230.60								
20.18													

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75
-18.32							
-17.82							
-16.09							
-15.59	229.71	229.29					
-15.51	231.78	229.24					
-13.86	275.42	229.26					
-12.21	400.42	229.37	229.00				
-12.13	401.00	272.03	229.23	229.14	229.07		
-10.24	415.21	374.83	368.95	283.49	229.18		
-10.16	415.99	377.48	371.97	285.30	229.19		
-8.82	431.24	400.57	396.16	310.30	229.21		
-8.74	432.31	401.07	396.59	311.68	229.21		
-6.85	462.54	383.05	372.13	341.24	229.38		
-6.77	464.19	376.48	363.78	343.32	232.35	229.00	230.57
-5.44	493.94	466.88	467.27	449.58	411.75	408.42	230.44
-5.36	495.98	467.55				411.77	230.23
-3.46	526.88	487.34				435.78	230.07
-3.38	527.77	487.99				436.53	230.08
-2.05	538.07	496.51				446.00	230.15
-1.97	538.44	496.86				446.43	230.15
-0.08	539.38	499.98				452.14	230.50
0.00	538.92	500.04	499.88	482.13	452.42	452.06	230.71
0.67	537.47	509.01	505.55	481.80	446.77	442.94	231.21
1.34	538.92	500.04	499.89	482.14	452.42	452.07	230.71
1.42	539.38	499.98				452.15	230.50
3.31	538.45	496.87				446.44	230.15
3.39	538.08	496.51				446.01	230.15
4.72	527.79	488.00				436.53	230.08
4.80	526.89	487.35				435.78	230.07
6.70	496.01	467.56				411.77	230.23
6.78	493.97	466.89	467.27	449.58	411.75	408.42	230.44
8.11	464.22	376.49	363.79	343.32	232.35	229.00	230.57
8.19	462.58	383.07	372.14	341.24	229.38		
10.08	432.34	401.10	396.62	311.68	229.21		
10.16	431.27	400.60	396.19	310.30	229.21		
11.49	416.03	377.50	372.00	285.31	229.19		
11.57	415.24	374.85	368.97	283.50	229.18		
13.47	401.03	272.03	229.23	229.14	229.07		
13.55	400.45	229.37	229.00				
15.20	275.43	229.27					
16.85	231.78	229.24					
16.93	229.71	229.29					
17.43							
19.68							
20.18							

Average Rectangle Temperatures for LOMC

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73	4.50	4.58	7.22	9.86	9.94	10.45
-18.32													
-17.82	340.60	340.34	340.00	339.84									
-16.09	479.00	478.31	477.31	476.80									
-15.59					479.12		349.58	242.76	236.87	233.46	232.64	231.95	231.05
-15.51					488.35		399.68	336.46	319.64	294.89	281.75	271.92	258.42
-13.86					511.19		470.59	460.65	448.88	422.24	405.37	375.69	342.66
-12.21					525.61		499.64					441.80	
-12.13					541.34		520.53					453.02	
-10.24					556.91		541.13					464.27	
-10.16	612.51	611.28	608.81	607.14	580.35		552.32					472.78	
-8.82					603.83		563.33					481.32	
-8.74					612.65		573.50					494.27	
-6.85					621.13		583.42					507.22	
-6.77					626.67		601.25	602.21	600.11	589.68	581.09	530.31	
-5.44					632.27		619.27					553.52	
-5.36					638.48		626.32					563.84	
-3.46					644.52		633.04					573.80	
-3.38	672.82	672.35	671.41	670.74	652.03		635.86					577.51	
-2.05					659.56		638.60					581.07	
-1.97					660.47		639.47					581.82	
-0.08					661.12		640.13					582.36	
0.00					660.82		639.56	640.82	639.20	627.95	616.36	576.66	
0.67					660.82		639.56	640.83	639.21	627.95	616.37	576.66	
1.34					661.13		640.14					582.37	
1.42					660.48		639.49					581.83	
3.31					659.58		638.63					581.08	
3.39	672.86	672.39	671.46	670.79	652.07		635.89					577.53	
4.72					644.59		633.08					573.82	
4.80					638.56		626.37					563.86	
6.70					632.37		619.33					553.55	
6.78					626.77		601.33	602.25	600.15	589.71	581.13	530.34	
8.11					621.25		583.51					507.26	
8.19					612.79		573.59					494.31	
10.08					603.99		563.44					481.37	
10.16	612.77	611.54	609.06	607.39	580.57		552.46					472.83	
11.49					557.19		541.29					464.32	
11.57					541.66		520.70					453.06	
13.47					525.99		499.83					441.84	
13.55					511.65		470.81	460.79	448.98	422.29	405.41	375.71	342.68
15.20					488.93		399.91	336.57	319.70	294.91	281.76	271.93	258.42
16.85					479.73		349.77	242.78	236.87	233.46	232.64	231.95	231.05
16.93	485.34	484.64	483.63	483.11									
17.43	346.44	346.19	345.86	345.71									
19.68													
20.18													

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75	19.25
-18.32								
-17.82								
-16.09								
-15.59	230.00							
-15.51	241.43							
-13.86	283.62							
-12.21	325.71	239.91						
-12.13	365.77	311.26	277.70	242.72				
-10.24	395.88	373.31	327.43	256.79				
-10.16	406.32	386.55	340.93	263.50				
-8.82	416.30	398.60	353.68	270.10				
-8.74	419.74	388.21	355.41	277.88				
-6.85	421.57	373.86	355.12	286.57				
-6.77	450.37	418.60	405.99	359.25	320.38	274.61		
-5.44	481.09					320.22		
-5.36	494.44					326.96		
-3.46	507.50					333.12		
-3.38	512.59					335.69		
-2.05	517.47					338.18		
-1.97	518.67					339.81		
-0.08	519.58					341.35		
0.00	521.36	503.62	492.34	465.78	448.55	339.23		
0.67	521.36	503.62	492.35	465.78	448.55	339.23		
1.34	519.58					341.36		
1.42	518.67					339.81		
3.31	517.48					338.19		
3.39	512.59					335.69		
4.72	507.51					333.12		
4.80	494.45					326.96		
6.70	481.11					320.22		
6.78	450.39	418.61	405.99	359.25	320.38	274.61		
8.11	421.59	373.87	355.12	286.57				
8.19	419.77	388.23	355.42	277.88				
10.08	416.33	398.63	353.70	270.10				
10.16	406.35	386.57	340.95	263.50				
11.49	395.91	373.33	327.45	256.79				
11.57	365.79	311.27	277.71	242.72				
13.47	325.72	239.91						
13.55	283.63							
15.20	241.43							
16.85	230.00							
16.93								
17.43								
19.68								
20.18								

Ex: At (0.0,-17.82), T_{avg} = (230.64 + 230.63+450.71+450.42)/4 = 340.60 °F

Rectangle Areas for LOMC

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73	4.50	4.58	7.22	9.86	9.94	10.45
-18.32													
-17.82	1.52	1.52	1.52	0.14									
-16.09	0.44	0.44	0.44	0.04									
-15.59					0.06		0.06	0.01	0.21	0.21	0.01	0.04	0.02
-15.51					1.25		1.27	0.13	4.36	4.36	0.13	0.84	0.41
-13.86					1.25		1.27	0.13	4.36	4.36	0.13	0.84	0.41
-12.21					0.06		0.06					0.04	
-12.13					1.44		1.46					0.96	
-10.24					0.06		0.06					0.04	
-10.16	1.18	1.18	1.18	0.11	1.02		1.03					0.68	
-8.82					0.06		0.06					0.04	
-8.74					1.44		1.46					0.96	
-6.85					0.06		0.06					0.04	
-6.77					1.01		1.02	0.11	3.51	3.51	0.11	0.68	
-5.44					0.06		0.06					0.04	
-5.36					1.44		1.46					0.97	
-3.46					0.06		0.06					0.04	
-3.38	1.17	1.17	1.17	0.11	1.01		1.02					0.68	
-2.05					0.06		0.06					0.04	
-1.97					1.44		1.46					0.96	
-0.08					0.06		0.06					0.04	
0.00					0.51		0.52	0.05	1.77	1.77	0.05	0.34	
0.67					0.51		0.52	0.05	1.77	1.77	0.05	0.34	
1.34					0.06		0.06					0.04	
1.42					1.44		1.46					0.96	
3.31					0.06		0.06					0.04	
3.39	1.17	1.17	1.17	0.11	1.01		1.02					0.68	
4.72					0.06		0.06					0.04	
4.80					1.44		1.46					0.97	
6.70					0.06		0.06					0.04	
6.78					1.01		1.02	0.11	3.51	3.51	0.11	0.68	
8.11					0.06		0.06					0.04	
8.19					1.44		1.46					0.96	
10.08					0.06		0.06					0.04	
10.16	1.17	1.17	1.17	0.11	1.01		1.02					0.68	
11.49					0.06		0.06					0.04	
11.57					1.44		1.46					0.97	
13.47					0.06		0.06					0.04	
13.55					1.25		1.27	0.13	4.36	4.36	0.13	0.84	0.41
15.20					1.25		1.27	0.13	4.36	4.36	0.13	0.84	0.41
16.85					0.06		0.06	0.01	0.21	0.21	0.01	0.04	0.02
16.93	0.44	0.44	0.44	0.04									
17.43	1.98	1.98	1.98	0.18									
19.68													
20.18													

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75	19.25
-18.32								
-17.82								
-16.09								
-15.59	0.04							
-15.51	0.87							
-13.86	0.87							
-12.21	0.04	0.01						
-12.13	1.00	0.15	4.97	4.99				
-10.24	0.04	0.01	0.21	0.21				
-10.16	0.71	0.11	3.52	3.54				
-8.82	0.04	0.01	0.21	0.21				
-8.74	1.00	0.15	4.97	4.99				
-6.85	0.04	0.01	0.21	0.21				
-6.77	0.70	0.11	3.50	3.51	0.11	2.78		
-5.44	0.04					0.17		
-5.36	1.01					3.97		
-3.46	0.04					0.17		
-3.38	0.70					2.78		
-2.05	0.04					0.17		
-1.97	1.00					3.95		
-0.08	0.04					0.17		
0.00	0.36	0.05	1.76	1.77	0.05	1.40		
0.67	0.36	0.05	1.76	1.77	0.05	1.40		
1.34	0.04					0.17		
1.42	1.00					3.95		
3.31	0.04					0.17		
3.39	0.70					2.78		
4.72	0.04					0.17		
4.80	1.01					3.97		
6.70	0.04					0.17		
6.78	0.70	0.11	3.50	3.51	0.11	2.78		
8.11	0.04	0.01	0.21	0.21				
8.19	1.00	0.15	4.97	4.99				
10.08	0.04	0.01	0.21	0.21				
10.16	0.70	0.11	3.50	3.51				
11.49	0.04	0.01	0.21	0.21				
11.57	1.01	0.15	5.00	5.02				
13.47	0.04	0.01						
13.55	0.87							
15.20	0.87							
16.85	0.04							
16.93								
17.43								
19.68								
20.18								

Ex. For (0.00, -17.82),
$A = (.88-0)(-16.09-(-17.82))$
$= 1.52 \text{ in}^2$

Product of Rectangle Area and Average Rectangle Temperature For LOMC

AVERAGE ARGON TEMPERATURE: T_{avg} = 430.52 °F

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73	4.50	4.58	7.22	9.86	9.94	10.45
-18.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-17.82	518.53	518.13	517.62	47.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-16.09	210.76	210.46	210.02	19.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-15.59	0.00	0.00	0.00	0.00	29.13	0.00	21.53	1.55	50.03	49.31	1.49	9.46	4.62
-15.51	0.00	0.00	0.00	0.00	612.39	0.00	507.79	44.41	1392.33	1284.54	37.19	228.82	106.60
-13.86	0.00	0.00	0.00	0.00	641.04	0.00	597.88	60.81	1955.32	1839.27	53.51	316.14	141.35
-12.21	0.00	0.00	0.00	0.00	31.96	0.00	30.78	0.00	0.00	0.00	0.00	18.03	0.00
-12.13	0.00	0.00	0.00	0.00	777.58	0.00	757.52	0.00	0.00	0.00	0.00	436.67	0.00
-10.24	0.00	0.00	0.00	0.00	33.86	0.00	33.33	0.00	0.00	0.00	0.00	18.94	0.00
-10.16	722.27	720.82	717.91	65.08	591.02	0.00	569.88	0.00	0.00	0.00	0.00	323.10	0.00
-8.82	0.00	0.00	0.00	0.00	36.71	0.00	34.70	0.00	0.00	0.00	0.00	19.64	0.00
-8.74	0.00	0.00	0.00	0.00	880.01	0.00	834.61	0.00	0.00	0.00	0.00	476.42	0.00
-6.85	0.00	0.00	0.00	0.00	37.76	0.00	35.94	0.00	0.00	0.00	0.00	20.69	0.00
-6.77	0.00	0.00	0.00	0.00	633.44	0.00	615.74	64.08	2107.12	2070.48	61.83	359.71	0.00
-5.44	0.00	0.00	0.00	0.00	38.44	0.00	38.15	0.00	0.00	0.00	0.00	22.58	0.00
-5.36	0.00	0.00	0.00	0.00	921.96	0.00	916.30	0.00	0.00	0.00	0.00	546.36	0.00
-3.46	0.00	0.00	0.00	0.00	39.19	0.00	39.00	0.00	0.00	0.00	0.00	23.41	0.00
-3.38	787.47	786.92	785.82	71.37	659.07	0.00	651.18	0.00	0.00	0.00	0.00	391.72	0.00
-2.05	0.00	0.00	0.00	0.00	40.10	0.00	39.34	0.00	0.00	0.00	0.00	23.71	0.00
-1.97	0.00	0.00	0.00	0.00	948.70	0.00	930.62	0.00	0.00	0.00	0.00	560.81	0.00
-0.08	0.00	0.00	0.00	0.00	40.20	0.00	39.43	0.00	0.00	0.00	0.00	23.76	0.00
0.00	0.00	0.00	0.00	0.00	336.49	0.00	329.95	34.35	1130.62	1110.71	33.04	197.04	0.00
0.67	0.00	0.00	0.00	0.00	336.49	0.00	329.95	34.35	1130.63	1110.72	33.04	197.05	0.00
1.34	0.00	0.00	0.00	0.00	40.20	0.00	39.43	0.00	0.00	0.00	0.00	23.76	0.00
1.42	0.00	0.00	0.00	0.00	948.71	0.00	930.65	0.00	0.00	0.00	0.00	560.83	0.00
3.31	0.00	0.00	0.00	0.00	40.10	0.00	39.34	0.00	0.00	0.00	0.00	23.71	0.00
3.39	787.52	786.96	785.87	71.37	659.11	0.00	651.21	0.00	0.00	0.00	0.00	391.74	0.00
4.72	0.00	0.00	0.00	0.00	39.19	0.00	39.00	0.00	0.00	0.00	0.00	23.41	0.00
4.80	0.00	0.00	0.00	0.00	922.08	0.00	916.37	0.00	0.00	0.00	0.00	546.38	0.00
6.70	0.00	0.00	0.00	0.00	38.45	0.00	38.15	0.00	0.00	0.00	0.00	22.58	0.00
6.78	0.00	0.00	0.00	0.00	633.54	0.00	615.82	64.08	2107.24	2070.60	61.83	359.73	0.00
8.11	0.00	0.00	0.00	0.00	37.77	0.00	35.94	0.00	0.00	0.00	0.00	20.70	0.00
8.19	0.00	0.00	0.00	0.00	880.21	0.00	834.75	0.00	0.00	0.00	0.00	476.46	0.00
10.08	0.00	0.00	0.00	0.00	36.72	0.00	34.71	0.00	0.00	0.00	0.00	19.64	0.00
10.16	717.18	715.74	712.85	64.63	586.84	0.00	565.77	0.00	0.00	0.00	0.00	320.72	0.00
11.49	0.00	0.00	0.00	0.00	33.88	0.00	33.34	0.00	0.00	0.00	0.00	18.94	0.00
11.57	0.00	0.00	0.00	0.00	782.16	0.00	761.78	0.00	0.00	0.00	0.00	439.02	0.00
13.47	0.00	0.00	0.00	0.00	31.98	0.00	30.79	0.00	0.00	0.00	0.00	18.03	0.00
13.55	0.00	0.00	0.00	0.00	641.62	0.00	598.17	60.82	1955.74	1839.47	53.51	316.16	141.36
15.20	0.00	0.00	0.00	0.00	613.12	0.00	508.09	44.43	1392.60	1284.64	37.19	228.83	106.60
16.85	0.00	0.00	0.00	0.00	29.17	0.00	21.55	1.55	50.03	49.31	1.49	9.46	4.62
16.93	213.55	213.24	212.80	19.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17.43	685.96	685.45	684.80	62.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75	19.25
-18.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-17.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-16.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-15.59	9.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-15.51	211.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-13.86	248.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-12.21	13.81	1.54	0.00	0.00	0.00	0.00	0.00	0.00
-12.13	366.39	47.06	1380.38	1211.08	0.00	0.00	0.00	0.00
-10.24	16.79	2.39	68.89	54.23	0.00	0.00	0.00	0.00
-10.16	288.57	41.44	1201.51	932.16	0.00	0.00	0.00	0.00
-8.82	17.65	2.55	74.41	57.05	0.00	0.00	0.00	0.00
-8.74	420.46	58.70	1766.64	1386.50	0.00	0.00	0.00	0.00
-6.85	17.87	2.39	74.72	60.52	0.00	0.00	0.00	0.00
-6.77	317.47	44.54	1420.10	1261.40	34.09	763.33	0.00	0.00
-5.44	20.40	0.00	0.00	0.00	0.00	53.54	0.00	0.00
-5.36	497.90	0.00	0.00	0.00	0.00	1298.37	0.00	0.00
-3.46	21.52	0.00	0.00	0.00	0.00	55.70	0.00	0.00
-3.38	361.32	0.00	0.00	0.00	0.00	933.12	0.00	0.00
-2.05	21.94	0.00	0.00	0.00	0.00	56.54	0.00	0.00
-1.97	519.55	0.00	0.00	0.00	0.00	1342.26	0.00	0.00
-0.08	22.03	0.00	0.00	0.00	0.00	57.07	0.00	0.00
0.00	185.13	26.99	867.55	823.87	24.04	475.02	0.00	0.00
0.67	185.13	26.99	867.56	823.88	24.04	475.03	0.00	0.00
1.34	22.03	0.00	0.00	0.00	0.00	57.07	0.00	0.00
1.42	519.55	0.00	0.00	0.00	0.00	1342.28	0.00	0.00
3.31	21.94	0.00	0.00	0.00	0.00	56.54	0.00	0.00
3.39	361.33	0.00	0.00	0.00	0.00	933.12	0.00	0.00
4.72	21.52	0.00	0.00	0.00	0.00	55.70	0.00	0.00
4.80	497.91	0.00	0.00	0.00	0.00	1298.37	0.00	0.00
6.70	20.40	0.00	0.00	0.00	0.00	53.54	0.00	0.00
6.78	317.48	44.54	1420.11	1261.40	34.09	763.33	0.00	0.00
8.11	17.88	2.39	74.72	60.52	0.00	0.00	0.00	0.00
8.19	420.49	58.70	1766.69	1386.50	0.00	0.00	0.00	0.00
10.08	17.65	2.55	74.42	57.05	0.00	0.00	0.00	0.00
10.16	286.44	41.13	1192.61	925.21	0.00	0.00	0.00	0.00
11.49	16.79	2.39	68.89	54.24	0.00	0.00	0.00	0.00
11.57	368.35	47.31	1387.72	1217.50	0.00	0.00	0.00	0.00
13.47	13.81	1.54	0.00	0.00	0.00	0.00	0.00	0.00
13.55	248.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.20	211.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.85	9.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

6. HEATING6 Output - Basket Spacer Disk Temperature Distribution During Accident Conditions

Temperature Distribution of Argon Filled Cask During FFE

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73	4.50	4.58	7.22	9.86	9.94	10.45
-18.32	453.70	453.70	453.70	453.70	453.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-17.82	455.14	455.13	455.12	455.11	455.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-16.09	583.29	582.98	582.20	581.49	581.48	0.00	0.00	453.70	453.70	453.70	453.70	453.70	453.70
-15.59	618.94	618.44	617.08	615.40	615.32	576.49	576.22	455.89	455.54	455.09	454.88	454.84	454.45
-15.51	619.28	618.77	617.40	615.72	615.65	576.50	576.10	470.82	464.39	459.09	457.43	457.27	456.03
-13.86	646.45	645.33	641.99	636.74	636.61	585.63	585.16	562.13	560.12	538.19	510.34	507.81	488.79
-12.21	664.68	664.07	662.10	658.04	657.90	611.69	611.21	616.39	617.86	615.39	601.38	600.16	543.85
-12.13	665.38	664.77	662.78	658.83	658.70	613.43	613.26	618.19	618.23	615.71	601.69	601.53	544.12
-10.24	678.44	678.00	676.72	674.79	674.71	649.41	649.34	650.47	650.48	645.65	625.59	625.40	554.63
-10.16	678.58	678.14	676.86	674.99	675.48	650.70	650.66	651.70	651.73	646.83	626.51	626.32	555.22
-8.82	736.45	735.84	733.95	730.46	729.54	671.35	671.29	665.82	665.81	661.27	640.64	640.44	566.80
-8.74	736.60	736.00	734.10	730.66	730.44	672.67	672.49	666.51	666.50	661.91	641.45	641.24	567.63
-6.85	742.79	742.34	740.91	738.47	738.31	692.20	691.96	678.75	678.71	673.22	658.51	658.30	591.70
-6.77	743.01	742.57	741.17	738.76	738.60	692.83	692.42	679.41	678.83	673.34	658.64	658.62	593.23
-5.44	746.11	745.80	744.83	743.12	742.99	706.43	706.06	722.60	723.19	721.33	708.12	707.22	618.03
-5.36	746.26	745.96	745.01	743.34	743.21	707.45	707.33	723.26	723.33	721.46	708.26	707.97	619.54
-3.46	748.83	748.63	748.03	747.11	747.04	724.07	724.02	729.42	729.45	727.04	715.37	715.14	645.41
-3.38	748.89	748.68	748.08	747.18	747.30	724.50	724.49	729.62	729.64	727.21	715.60	715.37	646.15
-2.05	767.84	767.65	767.08	766.07	765.64	730.95	730.93	732.22	732.22	729.54	718.66	718.45	654.32
-1.97	767.90	767.71	767.14	766.16	766.02	731.36	731.26	732.32	732.33	729.63	718.79	718.58	654.60
-0.08	768.57	768.40	767.88	767.03	766.90	732.39	732.24	733.42	733.43	730.63	720.07	719.85	654.20
0.00	768.58	768.41	767.89	767.04	766.92	732.19	731.87	733.42	733.43	730.62	720.07	719.74	654.01
0.67	768.63	768.46	767.94	767.09	766.96	731.02	730.60	732.82	732.96	730.05	709.19	703.23	652.59
1.34	768.58	768.41	767.89	767.05	766.92	732.19	731.88	731.42	733.43	730.63	720.07	719.74	654.01
1.42	768.57	768.40	767.88	767.03	766.91	732.39	732.24	733.43	733.43	730.63	720.08	719.86	654.21
3.31	767.90	767.71	767.14	766.16	766.02	731.37	731.27	732.33	732.34	729.64	718.80	718.59	654.60
3.39	767.84	767.65	767.08	766.08	765.65	730.97	730.94	732.22	732.23	729.54	718.67	718.46	654.32
4.72	748.92	748.71	748.12	747.22	747.33	724.52	724.51	729.63	729.65	727.22	715.61	715.38	646.16
4.80	748.87	748.66	748.06	747.14	747.07	724.09	724.04	729.43	729.46	727.04	715.37	715.15	645.42
6.70	746.30	745.99	745.05	743.38	743.25	707.48	707.36	723.27	723.34	721.47	708.27	707.98	619.55
6.78	746.15	745.84	744.87	743.16	743.04	706.46	706.10	722.61	723.21	721.34	708.13	707.23	618.04
8.11	743.06	742.62	741.22	738.81	738.65	692.87	692.46	679.43	678.86	673.35	658.66	658.64	593.24
8.19	742.84	742.39	740.96	738.52	738.37	692.24	692.01	678.78	678.73	673.24	658.53	658.32	591.72
10.08	736.66	736.06	734.16	730.72	730.51	672.73	672.55	666.54	666.53	661.93	641.47	641.27	567.64
10.16	736.51	735.90	734.01	730.53	729.60	671.41	671.36	665.85	665.84	661.29	640.67	640.47	566.81
11.49	678.72	678.28	677.00	675.12	675.61	650.79	650.75	651.75	651.77	646.87	626.54	626.35	555.23
11.57	678.57	678.13	676.85	674.92	674.85	649.50	649.43	650.52	650.53	645.68	625.62	625.43	554.64
13.47	665.55	664.93	662.94	659.01	658.88	613.56	613.38	618.23	618.26	615.74	601.71	601.55	544.13
13.55	664.86	664.23	662.26	658.24	658.10	611.82	611.34	616.43	617.90	615.42	601.40	600.18	543.86
15.20	646.97	645.86	642.50	637.16	637.03	585.80	585.33	562.22	560.20	538.22	510.35	507.82	488.80
16.85	619.81	619.30	617.92	616.20	616.13	576.68	576.27	470.84	464.40	459.09	457.43	457.27	456.04
16.93	619.48	618.97	617.59	615.88	615.80	576.67	576.39	455.89	455.54	455.09	454.88	454.84	454.45
17.43	590.41	590.10	589.34	588.67	588.67	0.00	0.00	453.70	453.70	453.70	453.70	453.70	453.70
19.68	455.13	455.13	455.12	455.10	455.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.18	453.70	453.70	453.70	453.70	453.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75	19.25
-18.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-17.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-16.09	453.70	453.70	0.00	0.00	0.00	0.00	0.00	0.00
-15.59	454.32	453.95	453.70	0.00	0.00	0.00	0.00	0.00
-15.51	455.40	453.91	453.70	0.00	0.00	0.00	0.00	0.00
-13.86	478.63	453.93	453.70	0.00	0.00	0.00	0.00	0.00
-12.21	543.30	454.02	453.70	453.70	453.70	0.00	0.00	0.00
-12.13	543.75	481.57	453.90	453.83	453.76	453.70	0.00	0.00
-10.24	554.19	532.04	528.79	482.11	453.86	453.70	0.00	0.00
-10.16	554.77	533.54	530.52	483.07	453.86	453.70	0.00	0.00
-8.82	566.31	547.91	545.28	496.35	453.89	453.70	0.00	0.00
-8.74	567.13	548.24	545.55	497.08	453.89	453.70	0.00	0.00
-6.85	591.11	538.10	530.67	512.25	454.04	453.70	0.00	0.00
-6.77	592.47	534.83	525.04	513.32	456.51	453.70	455.16	453.70
-5.44	617.33	596.22	596.63	582.52	552.05	548.99	455.03	453.70
-5.36	619.14	596.92	596.85	582.71	552.34	552.07	454.81	453.70
-3.46	645.10	614.15	614.06	598.81	571.75	571.52	454.67	453.70
-3.38	645.83	614.71	614.63	599.34	572.35	572.12	454.67	453.70
-2.05	654.01	622.09	622.00	606.24	579.92	579.68	454.74	453.70
-1.97	654.29	622.39	622.31	606.54	580.26	580.02	454.75	453.70
-0.08	653.84	625.07	624.99	609.69	584.69	584.43	455.10	453.70
0.00	653.34	625.12	624.98	609.68	584.70	584.38	455.31	453.70
0.67	651.74	631.37	628.89	609.42	581.44	578.99	455.79	453.70
1.34	653.34	625.12	624.98	609.69	584.70	584.38	455.31	453.70
1.42	653.84	625.07	624.99	609.69	584.69	584.43	455.10	453.70
3.31	654.30	622.40	622.31	606.54	580.27	580.02	454.75	453.70
3.39	654.02	622.09	622.00	606.24	579.92	579.68	454.74	453.70
4.72	645.84	614.72	614.63	599.34	572.35	572.12	454.67	453.70
4.80	645.10	614.15	614.07	598.81	571.75	571.52	454.67	453.70
6.70	619.15	596.92	596.86	582.72	552.34	552.07	454.81	453.70
6.78	617.34	596.23	596.63	582.52	552.05	548.99	455.03	453.70
8.11	592.49	534.84	525.05	513.32	456.51	453.70	455.16	453.70
8.19	591.12	538.11	530.68	512.25	454.04	453.70	0.00	0.00
10.08	567.15	548.25	545.56	497.08	453.89	453.70	0.00	0.00
10.16	566.32	547.92	545.29	496.35	453.89	453.70	0.00	0.00
11.49	554.79	533.55	530.53	483.07	453.86	453.70	0.00	0.00
11.57	554.20	532.05	528.80	482.12	453.86	453.70	0.00	0.00
13.47	543.76	481.57	453.90	453.83	453.76	453.70	0.00	0.00
13.55	543.31	454.02	453.70	453.70	453.70	0.00	0.00	0.00
15.20	478.63	453.93	453.70	0.00	0.00	0.00	0.00	0.00
16.85	455.40	453.91	453.70	0.00	0.00	0.00	0.00	0.00
16.93	454.32	453.95	453.70	0.00	0.00	0.00	0.00	0.00
17.43	453.70	453.70	0.00	0.00	0.00	0.00	0.00	0.00
19.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Temperature Distribution of Argon Replaced by Steel Case During PFZ

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73	4.50	4.58	7.22	9.86	9.94	10.45
-18.32	453.70	453.70	453.70	453.70	453.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-17.82	454.93	454.94	454.96	454.99	454.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-16.09	459.12	459.16	459.30	459.57	459.57	0.00	0.00	453.70	453.70	453.70	453.70	453.70	453.70
-15.59	460.28	460.30	460.46	461.21	461.41	461.43	460.93	457.69	457.24	455.16	454.21	454.19	454.01
-15.51	460.55	460.57	460.71	461.49	461.57	461.44	460.95	458.03	457.73	455.39	454.30	454.26	454.05
-13.86	474.09	473.51	471.63	468.00	467.85	466.80	466.37	464.83	464.67	459.86	455.97	455.85	455.07
-12.21	483.24	482.55	480.21	475.43	475.25	473.93	473.41	471.48	471.21	463.97	457.71	457.55	456.47
-12.13	483.56	482.85	480.61	475.83	475.65	474.32	473.81	471.95	471.64	464.25	457.81	457.65	456.63
-10.24	490.80	490.37	488.97	486.23	486.01	484.82	484.55	484.16	484.16	479.49	464.55	464.30	463.22
-10.16	490.85	490.42	489.06	486.60	486.39	485.18	484.92	484.55	484.55	480.00	464.83	464.58	463.50
-8.82	492.48	492.17	491.35	490.43	490.40	490.15	490.11	490.19	490.24	485.80	469.62	469.35	468.15
-8.74	492.69	492.39	491.57	490.66	490.64	490.43	490.40	490.48	490.53	486.14	469.92	469.65	468.43
-6.85	501.22	500.82	499.54	497.15	497.02	496.37	496.23	496.03	496.06	491.09	477.75	477.30	475.34
-6.77	501.47	501.07	499.78	497.37	497.24	496.58	496.43	496.17	496.15	491.12	478.00	477.62	475.60
-5.44	504.67	504.28	503.01	500.58	500.43	499.56	499.28	498.40	498.26	492.50	480.68	480.47	479.21
-5.36	504.81	504.42	503.17	500.76	500.61	499.74	499.46	498.61	498.48	492.69	480.81	480.61	479.46
-3.46	506.82	506.58	505.85	504.55	504.43	503.77	503.63	503.43	503.44	499.98	488.03	487.82	487.01
-3.38	506.83	506.59	505.87	504.67	504.57	503.90	503.76	503.57	503.58	500.16	488.29	488.07	487.26
-2.05	507.54	507.33	506.74	505.89	505.83	505.41	505.32	505.22	505.23	502.21	491.45	491.24	490.45
-1.97	507.64	507.44	506.85	505.96	505.89	505.47	505.39	505.29	505.30	502.28	491.59	491.37	490.58
-0.08	509.77	509.51	508.67	507.14	507.02	506.38	506.20	505.79	505.75	501.97	493.12	492.87	491.80
0.00	509.81	509.54	508.70	507.16	507.04	506.39	506.21	505.77	505.71	501.91	493.16	492.94	491.82
0.67	509.95	509.68	508.82	507.24	507.12	506.44	506.24	505.69	505.62	501.76	493.28	493.08	491.87
1.34	509.82	509.55	508.71	507.17	507.05	506.39	506.22	505.77	505.71	501.91	493.16	492.94	491.83
1.42	509.78	509.51	508.68	507.15	507,03	506.38	506.21	505.79	505.75	501.97	493.12	492.88	491.81
3.31	507.67	507.46	506.87	505.98	505.91	505.49	505.41	505.30	505.32	502.29	491.59	491.38	490.59
3.39	507.56	507.35	506.76	505.91	505.85	505.43	505.34	505.24	505.25	502.23	491.46	491.25	490.46
4.72	506.86	506.62	505.90	504.70	504.60	503.93	503.79	503.60	503.61	500.18	488.30	488.08	487.27
4.80	506.85	506.61	505.88	504.58	504.46	503.81	503.66	503.46	503.47	500.00	488.05	487.83	487.03
6.70	504.86	504.47	503.22	500.81	500.66	499.79	499.51	498.66	498.53	492.73	480.83	480.63	479.48
6.78	504.72	504.33	503.06	500.63	500.49	499.62	499.34	498.45	498.31	492.54	480.70	480.49	479.23
8.11	501.54	501.13	499.85	497.44	497.31	496.65	496.50	496.24	496.21	491.16	478.02	477.64	475.62
8.19	501.29	500.89	499.61	497.22	497.09	496.44	496.30	496.10	496.12	491.13	477.76	477.31	475.36
10.08	492.82	492.52	491.70	490.78	490.76	490.54	490.50	490.58	490.63	486.20	469.94	469.67	468.45
10.16	492.61	492.30	491.48	490.55	490.52	490.26	490.22	490.29	490.34	485.86	469.64	469.37	468.16
11.49	490.99	490.56	489.20	486.74	486.53	485.31	485.06	484.68	484.68	480.08	464.85	464.60	463.51
11.57	490.94	490.51	489.11	486.36	486.15	484.95	484.69	484.28	484.29	479.57	464.56	464.32	463.23
13.47	483.85	483.12	480.86	476.02	475.84	474.50	473.98	472.11	471.79	464.31	457.83	457.67	456.64
13.55	483.53	482.81	480.47	475.63	475.45	474.11	473.58	471.64	471.37	464.03	457.73	457.56	456.48
15.20	474.60	474.00	472.04	468.28	468.13	467.03	466.58	464.98	464.82	459.92	455.99	455.87	455.08
16.85	461.44	461.44	461.50	462.04	462.09	461.77	461.21	458.13	457.82	455.41	454.30	454.27	454.06
16.93	461.18	461.18	461.26	461.79	461.96	461.76	461.20	457.79	457.32	455.17	454.22	454.19	454.01
17.43	460.06	460.08	460.16	460.34	460.34	0.00	0.00	453.70	453.70	453.70	453.70	453.70	453.70
19.68	454.86	454.87	454.88	454.89	454.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.18	453.70	453.70	453.70	453.70	453.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75	19.25
-18.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-17.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-16.09	453.70	453.70	0.00	0.00	0.00	0.00	0.00	0.00
-15.59	453.92	453.75	453.70	0.00	0.00	0.00	0.00	0.00
-15.51	453.95	453.74	453.70	0.00	0.00	0.00	0.00	0.00
-13.86	454.68	453.83	453.70	0.00	0.00	0.00	0.00	0.00
-12.21	455.81	454.08	453.70	453.70	453.70	0.00	0.00	0.00
-12.13	455.99	454.41	454.17	453.85	453.70	453.70	0.00	0.00
-10.24	462.70	461.61	461.46	457.44	453.81	453.70	0.00	0.00
-10.16	462.98	461.89	461.74	457.59	453.81	453.70	0.00	0.00
-8.82	467.55	466.30	466.11	459.99	453.89	453.70	0.00	0.00
-8.74	467.83	466.56	466.37	460.13	453.89	453.70	0.00	0.00
-6.85	474.44	472.62	472.35	463.49	454.06	453.70	0.00	0.00
-6.77	474.69	472.87	472.59	463.64	454.13	453.70	453.88	453.70
-5.44	478.54	476.96	476.66	466.19	456.40	456.25	454.20	453.70
-5.36	478.82	477.36	477.03	466.41	456.49	456.36	454.22	453.70
-3.46	486.71	486.27	486.22	477.04	459.08	458.81	454.67	453.70
-3.38	486.96	486.55	486.51	477.33	459.17	458.90	454.69	453.70
-2.05	490.17	489.80	489.77	480.35	460.39	460.10	454.93	453.70
-1.97	490.30	489.92	489.88	480.43	460.47	460.17	454.95	453.70
-0.08	491.32	490.42	490.25	479.32	462.26	461.89	455.25	453.70
0.00	491.33	490.35	490.15	479.26	462.36	461.97	455.25	453.70
0.67	491.31	490.12	489.91	479.08	462.62	462.25	455.28	453.70
1.34	491.33	490.35	490.15	479.26	462.36	461.97	455.25	453.70
1.42	491.32	490.42	490.25	479.32	462.26	461.89	455.25	453.70
3.31	490.31	489.93	489.89	480.44	460.47	460.17	454.95	453.70
3.39	490.18	489.81	489.77	480.35	460.39	460.10	454.93	453.70
4.72	486.97	486.56	486.52	477.34	459.17	458.90	454.69	453.70
4.80	486.72	486.28	486.23	477.05	459.08	458.81	454.67	453.70
6.70	478.84	477.37	477.04	466.42	456.49	456.36	454.22	453.70
6.78	478.56	476.98	476.67	466.20	456.40	456.25	454.20	453.70
8.11	474.71	472.89	472.61	463.65	454.13	453.70	453.88	453.70
8.19	474.45	472.64	472.36	463.50	454.06	453.70	0.00	0.00
10.08	467.84	466.57	466.38	460.13	453.89	453.70	0.00	0.00
10.16	467.57	466.31	466.12	459.99	453.89	453.70	0.00	0.00
11.49	462.99	461.90	461.74	457.59	453.81	453.70	0.00	0.00
11.57	462.71	461.62	461.46	457.44	453.81	453.70	0.00	0.00
13.47	456.00	454.41	454.17	453.85	453.70	453.70	0.00	0.00
13.55	455.82	454.08	453.70	453.70	453.70	0.00	0.00	0.00
15.20	454.69	453.83	453.70	0.00	0.00	0.00	0.00	0.00
16.85	453.96	453.74	453.70	0.00	0.00	0.00	0.00	0.00
16.93	453.92	453.75	453.70	0.00	0.00	0.00	0.00	0.00
17.43	453.70	453.70	0.00	0.00	0.00	0.00	0.00	0.00
19.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Spacer Disk Temperature Distribution for PTE

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73	4.50	4.58	7.22	9.86	9.94	10.45
-18.32													
-17.82	455.04	455.04	455.04	455.05	455.05								
-16.09	521.20	521.07	520.75	520.53	520.53								
-15.59	539.61	539.37	538.77	538.31	538.37	518.96	518.57	456.79	456.39	455.13	454.55	454.52	454.23
-15.51					538.61	518.97	518.53	464.43	461.06	457.24	455.87	455.77	455.04
-13.86					552.23	526.21	525.77	513.48	512.40	499.03	483.16	481.83	471.93
-12.21					566.58	542.81	542.31	543.94	544.53	539.68	529.55	528.86	500.16
-12.13					567.18	543.88	543.54	545.07				529.59	500.38
-10.24					580.36	567.12	566.95	567.32				544.85	508.93
-10.16	584.72	584.28	582.96	580.80	580.94	567.94	567.79	568.13				545.45	509.36
-8.82	614.47	614.01	612.65	610.45	609.97	580.75	580.70	578.01				554.90	517.47
-8.74					610.54	581.55	581.45	578.50				555.45	518.03
-6.85					617.66	594.29	594.10	587.39				567.80	533.52
-6.77					617.92	594.71	594.43	587.79	587.49	582.23	568.32	568.12	534.41
-5.44					621.71	603.00	602.67	610.50	610.72	606.92	594.40	593.84	548.62
-5.36					621.91	603.59	603.40	610.94				594.29	549.50
-3.46					625.74	613.92	613.83	616.43				601.48	566.21
-3.38	627.86	627.64	626.97	625.93	625.94	614.20	614.13	616.59				601.72	566.71
-2.05	637.69	637.49	636.91	635.98	635.74	618.18	618.13	618.72				604.84	572.39
-1.97					635.96	618.41	618.33	618.81				604.97	572.59
-0.08					636.96	619.39	619.22	619.61				606.36	573.00
0.00					636.98	619.29	619.04	619.59	619.57	616.27	606.62	606.34	572.92
0.67					637.04	618.73	618.42	619.26	619.29	615.91	601.24	598.15	572.23
1.34					636.99	619.29	619.05	619.59	619.57	616.27	606.62	606.34	572.92
1.42					636.97	619.39	619.22	619.61				606.37	573.01
3.31					635.97	618.43	618.34	618.82				604.99	572.59
3.39	637.70	637.50	636.92	636.00	635.75	618.20	618.14	618.73				604.86	572.39
4.72	627.89	627.67	627.01	625.96	625.97	614.22	614.15	616.62				601.73	566.71
4.80					625.77	613.95	613.85	616.45				601.49	566.22
6.70					621.96	603.64	603.44	610.97				594.31	549.52
6.78					621.77	603.04	602.72	610.53	610.76	606.94	594.42	593.86	548.64
8.11					617.98	594.76	594.48	587.83	587.53	582.26	568.34	568.14	534.43
8.19					617.73	594.34	594.16	587.44				567.82	533.54
10.08					610.64	581.64	581.53	578.56				555.47	518.05
10.16	614.56	614.10	612.75	610.54	610.06	580.83	580.79	578.07				554.92	517.49
11.49	584.86	584.42	583.10	580.93	581.07	568.05	567.91	568.21				545.47	509.37
11.57					580.50	567.22	567.06	567.40				544.88	508.94
13.47					567.36	544.03	543.68	545.17				529.61	500.39
13.55					566.78	542.96	542.46	544.04	544.64	539.72	529.57	528.87	500.17
15.20					552.58	526.41	525.96	513.60	512.51	499.07	483.17	481.85	471.94
16.85					539.11	519.22	518.74	464.49	461.11	457.25	455.87	455.77	455.05
16.93	540.33	540.07	539.43	538.84	538.88	519.21	518.80	456.84	456.43	455.13	454.55	454.52	454.23
17.43	525.24	525.09	524.75	524.51	524.51								
19.68	455.00	455.00	455.00	455.00	455.00								
20.18													

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75	19.25
-18.32								
-17.82								
-16.09								
-15.59	454.12	453.85						
-15.51	454.68	453.83						
-13.86	466.66	453.88						
-12.21	499.56	454.05						
-12.13	499.87	467.99	454.04	453.84	453.73			
-10.24	508.45	496.83	495.13	469.78	453.84			
-10.16	508.88	497.72	496.13	470.33	453.84			
-8.82	516.93	507.11	505.70	478.17	453.89			
-8.74	517.48	507.40	505.96	478.61	453.89			
-6.85	532.78	505.36	501.51	487.87	454.05			
-6.77	533.58	503.85	498.82	488.48	455.32	453.70	454.52	
-5.44	547.94	536.59	536.65	524.36	504.22	502.62	454.62	
-5.36	548.98	537.14				504.22	454.52	
-3.46	565.90	550.21				515.17	454.67	
-3.38	566.40	550.63				515.51	454.68	
-2.05	572.09	555.95				519.89	454.84	
-1.97	572.30	556.16				520.10	454.85	
-0.08	572.58	557.75				523.16	455.18	
0.00	572.34	557.74	557.57	544.47	523.53	523.18	455.28	
0.67	571.53	560.75	559.40	544.25	522.03	520.62	455.54	
1.34	572.34	557.74	557.57	544.47	523.53	523.18	455.28	
1.42	572.58	557.75				523.16	455.18	
3.31	572.31	556.17				520.10	454.85	
3.39	572.10	555.95				519.89	454.84	
4.72	566.41	550.64				515.51	454.68	
4.80	565.91	550.22				515.17	454.67	
6.70	549.00	537.15				504.22	454.52	
6.78	547.95	536.61	536.65	524.36	504.22	502.62	454.62	
8.11	533.60	503.87	498.83	488.49	455.32	453.70	454.52	
8.19	532.79	505.38	501.52	487.88	454.05			
10.08	517.50	507.41	505.97	478.61	453.89			
10.16	516.95	507.12	505.71	478.17	453.89			
11.49	508.89	497.72	496.14	470.33	453.84			
11.57	508.46	496.84	495.13	469.78	453.84			
13.47	499.88	467.99	454.04	453.84	453.73			
13.55	499.57	454.05						
15.20	466.66	453.88						
16.85	454.68	453.83						
16.93	454.12	453.85						
17.43								
19.68								
20.18								

7. HEATING6 Output - Average Argon Temperature Distribution During Accident Conditions

Temperature Distribution of Argon in the Cask for PFZ

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73	4.50	4.58	7.22	9.86	9.94	10.45
-18.32													
-17.82	455.14	455.13	455.12	455.11	455.11								
-16.09	583.29	582.98	582.20	581.49	581.48								
-15.59	618.94	618.44	617.08	615.40	615.32	576.49	576.22	455.89	455.54	455.09	454.88	454.84	454.45
-15.51					615.65	576.50	576.10	470.82	464.39	459.09	457.43	457.27	456.03
-13.86					636.61	585.63	585.16	562.13	560.12	538.19	510.34	507.81	488.79
-12.21					657.90	611.69	611.21	616.39	617.86	615.39	601.38	600.16	543.85
-12.13					658.70	613.43	613.26	618.19				601.53	544.12
-10.24					674.71	649.41	649.34	650.47				625.40	554.63
-10.16	678.58	678.14	676.86	674.99	675.48	650.70	650.66	651.70				626.32	555.22
-8.82	736.45	735.84	733.95	730.46	729.54	671.35	671.29	665.82				640.44	566.80
-8.74					730.44	672.67	672.49	666.51				641.24	567.63
-6.85					738.31	692.20	691.96	678.75				658.30	591.70
-6.77					738.60	692.83	692.42	679.41	678.83	673.34	658.64	658.62	593.23
-5.44					742.99	706.43	706.06	722.60	723.19	721.33	708.12	707.22	618.03
-5.36					743.21	707.45	707.33	723.26				707.97	619.54
-3.46					747.04	724.07	724.02	729.42				715.14	645.41
-3.38	748.89	748.68	748.08	747.18	747.30	724.50	724.49	729.62				715.37	646.15
-2.05	767.84	767.65	767.08	766.07	765.64	730.95	730.93	732.22				718.45	654.32
-1.97					766.02	731.36	731.26	732.32				718.58	654.60
-0.08					766.90	732.39	732.24	733.42				719.85	654.20
0.00					766.92	732.19	731.87	733.42	733.43	730.62	720.07	719.74	654.01
0.67					766.96	731.02	730.60	732.82	732.96	730.05	709.19	703.23	652.59
1.34					766.92	732.19	731.88	733.42	733.43	730.63	720.07	719.74	654.01
1.42					766.91	732.39	732.24	733.43				719.86	654.21
3.31					766.02	731.37	731.27	732.33				718.59	654.60
3.39	767.84	767.65	767.08	766.08	765.65	730.97	730.94	732.22				718.46	654.32
4.72	748.92	748.71	748.12	747.22	747.33	724.52	724.51	729.63				715.38	646.16
4.80					747.07	724.09	724.04	729.43				715.15	645.42
6.70					743.25	707.48	707.36	723.27				707.98	619.55
6.78					743.04	706.46	706.10	722.61	723.21	721.34	708.13	707.23	618.04
8.11					738.65	692.87	692.46	679.43	678.86	673.35	658.66	658.64	593.24
8.19					738.37	692.24	692.01	678.78				658.32	591.72
10.08					730.51	672.73	672.55	666.54				641.27	567.64
10.16	736.51	735.90	734.01	730.53	729.60	671.41	671.36	665.85				640.47	566.81
11.49	678.72	678.28	677.00	675.12	675.61	650.79	650.75	651.75				626.35	555.23
11.57					674.85	649.50	649.43	650.52				625.43	554.64
13.47					658.88	613.56	613.38	618.23				601.55	544.13
13.55					658.10	611.82	611.34	616.43	617.90	615.42	601.40	600.18	543.86
15.20					637.03	585.80	585.33	562.22	560.20	538.22	510.35	507.82	488.80
16.85					616.13	576.68	576.27	470.84	464.40	459.09	457.43	457.27	456.04
16.93	619.48	618.97	617.59	615.88	615.80	576.67	576.39	455.89	455.54	455.09	454.88	454.84	454.45
17.43	590.41	590.10	589.34	588.67	588.67								
19.68	455.13	455.13	455.12	455.10	455.10								
20.18													

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75	19.25
-18.32								
-17.82								
-16.09								
-15.59	454.32	453.95						
-15.51	455.40	453.91						
-13.86	478.63	453.93						
-12.21	543.30	454.02	453.70					
-12.13	543.75	481.57	453.90	453.83	453.76			
-10.24	554.19	532.04	528.79	482.11	453.86			
-10.16	554.77	533.54	530.52	483.07	453.86			
-8.82	566.31	547.91	545.28	496.35	453.89			
-8.74	567.13	548.24	545.55	497.08	453.89			
-6.85	591.11	538.10	530.67	512.25	454.04			
-6.77	592.47	534.83	525.04	513.32	456.51	453.70	455.16	
-5.44	617.33	596.22	596.63	582.52	552.05	548.99	455.03	
-5.36	619.14	596.92				552.07	454.81	
-3.46	645.10	614.15				571.52	454.67	
-3.38	645.83	614.71				572.12	454.67	
-2.05	654.01	622.09				579.68	454.74	
-1.97	654.29	622.39				580.02	454.75	
-0.08	653.84	625.07				584.43	455.10	
0.00	653.34	625.12	624.98	609.68	584.70	584.38	455.31	
0.67	651.74	631.37	628.89	609.42	581.44	578.99	455.79	
1.34	653.34	625.12	624.98	609.69	584.70	584.38	455.31	
1.42	653.84	625.07				584.43	455.10	
3.31	654.30	622.40				580.02	454.75	
3.39	654.02	622.09				579.68	454.74	
4.72	645.84	614.72				572.12	454.67	
4.80	645.10	614.15				571.52	454.67	
6.70	619.15	596.92				552.07	454.81	
6.78	617.34	596.23	596.63	582.52	552.05	548.99	455.03	
8.11	592.49	534.84	525.05	513.32	456.51	453.70	455.16	
8.19	591.12	538.11	530.68	512.25	454.04			
10.08	567.15	548.25	545.56	497.08	453.89			
10.16	566.32	547.92	545.29	496.35	453.89			
11.49	554.79	533.55	530.53	483.07	453.86			
11.57	554.20	532.05	528.80	482.12	453.86			
13.47	543.76	481.57	453.90	453.83	453.76			
13.55	543.31	454.02	453.70					
15.20	478.63	453.93						
16.85	455.40	453.91						
16.93	454.32	453.95						
17.43								
19.68								
20.18								

Average Rectangle Temperatures for PFZ

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73	4.50	4.58	7.22	9.86	9.94	10.45
-18.32													
-17.82	519.14	518.86	518.48	518.30									
-16.09	600.91	600.18	599.04	598.42									
-15.59					595.99		519.76	461.66	458.53	456.62	456.11	455.65	455.05
-15.51					603.60		548.55	514.37	505.45	491.26	483.21	477.48	469.71
-13.86					622.96		593.72	589.13	582.89	566.33	554.92	535.15	513.64
-12.21					635.43		614.76					572.41	
-12.13					649.06		632.82					581.42	
-10.24					662.57		650.54					590.39	
-10.16	707.25	706.20	704.07	702.62	681.77		659.87					597.20	
-8.82					701.00		669.03					604.03	
-8.74					708.41		677.43					614.72	
-6.85					715.49		685.63					625.46	
-6.77					720.21		700.12	701.01	699.17	690.36	683.15	644.28	
-5.44					725.02		714.81					663.19	
-5.36					730.44		721.01					672.01	
-3.46					735.73		726.89					680.52	
-3.38	758.27	757.87	757.10	756.55	742.10		729.32					683.57	
-2.05					748.49		731.68					686.49	
-1.97					749.17		732.31					686.81	
-0.08					749.60		732.74					686.95	
0.00					749.27		732.18	733.16	731.77	722.48	713.06	682.39	
0.67					749.27		732.18	733.16	731.77	722.49	713.06	682.39	
1.34					749.60		732.74					686.95	
1.42					749.17		732.32					686.81	
3.31					748.50		731.69					686.49	
3.39	758.28	757.89	757.13	756.57	742.12		729.32					683.58	
4.72					735.75		726.90					680.53	
4.80					730.47		721.03					672.03	
6.70					725.06		714.84					663.20	
6.78					720.26		700.15	701.03	699.19	690.37	683.17	644.29	
8.11					715.53		685.67					625.48	
8.19					708.46		677.47					614.74	
10.08					701.06		669.07					604.05	
10.16	707.35	706.30	704.17	702.72	681.85		659.93					597.21	
11.49					662.69		650.61					590.41	
11.57					649.20		632.89					581.44	
13.47					635.59		614.84					572.43	
13.55					623.19		593.83	589.19	582.94	566.35	554.94	535.16	513.65
15.20					603.91		548.67	514.41	505.48	491.27	483.22	477.48	469.72
16.85					596.32		519.85	461.67	458.53	456.62	456.11	455.65	455.05
16.93	604.74	604.00	602.87	602.26									
17.43	522.69	522.42	522.06	521.89									
19.68													
20.18													

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75	19.25
-18.32								
-17.82								
-16.09								
-15.59	454.40							
-15.51	460.47							
-13.86	482.47							
-12.21	505.66	460.80						
-12.13	527.89	499.08	479.66	460.89				
-10.24	543.64	531.22	506.12	468.23				
-10.16	550.63	539.31	513.81	471.79				
-8.82	557.40	546.75	521.07	475.30				
-8.74	561.15	540.64	521.39	479.32				
-6.85	564.13	532.16	520.32	484.03				
-6.77	585.21	563.18	554.38	526.10	502.81	478.22		
-5.44	607.40					502.73		
-5.36	618.83					508.27		
-3.46	629.95					513.25		
-3.38	634.16					515.30		
-2.05	638.20					517.30		
-1.97	638.90					518.58		
-0.08	639.34					519.81		
0.00	640.39	627.59	618.24	596.31	582.38	518.62		
0.67	640.39	627.59	618.25	596.31	582.38	518.62		
1.34	639.34					519.81		
1.42	638.90					518.57		
3.31	638.20					517.30		
3.39	634.17					515.30		
4.72	629.95					513.25		
4.80	618.83					508.27		
6.70	607.41					502.73		
6.78	585.23	563.19	554.38	526.10	502.81	478.22		
8.11	564.14	532.17	520.33	484.03				
8.19	561.16	540.65	521.39	479.32				
10.08	557.41	546.76	521.07	475.30				
10.16	550.65	539.32	513.81	471.79				
11.49	543.65	531.23	506.13	468.23				
11.57	527.90	499.08	479.66	460.89				
13.47	505.67	460.80						
13.55	482.47							
15.20	460.47							
16.85	454.40							
16.93								
17.43								
19.68								
20.18								

Rectangle Areas for PFE

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73
-18.32							
-17.82	1.52	1.52	1.52	0.14			
-16.09	0.44	0.44	0.44	0.04			
-15.59					0.06		0.06
-15.51					1.25		1.27
-13.86					1.25		1.27
-12.21					0.06		0.06
-12.13					1.44		1.46
-10.24					0.06		0.06
-10.16	1.18	1.18	1.18	0.11	1.02		1.03
-8.82					0.06		0.06
-8.74					1.44		1.46
-6.85					0.06		0.06
-6.77					1.01		1.02
-5.44					0.06		0.06
-5.36					1.44		1.46
-3.46					0.06		0.06
-3.38	1.17	1.17	1.17	0.11	1.01		1.02
-2.05					0.06		0.06
-1.97					1.44		1.46
-0.08					0.06		0.06
0.00					0.51		0.52
0.67					0.51		0.52
1.34					0.06		0.06
1.42					1.44		1.46
3.31					0.06		0.06
3.39	1.17	1.17	1.17	0.11	1.01		1.02
4.72					0.06		0.06
4.80					1.44		1.46
6.70					0.06		0.06
6.78					1.01		1.02
8.11					0.06		0.06
8.19					1.44		1.46
10.08					0.06		0.06
10.16	1.17	1.17	1.17	0.11	1.01		1.02
11.49					0.06		0.06
11.57					1.44		1.46
13.47					0.06		0.06
13.55					1.25		1.27
15.20					1.25		1.27
16.85					0.06		0.06
16.93	0.44	0.44	0.44	0.04			
17.43	1.98	1.98	1.98	0.18			
19.68							
20.18							

DISTANCE	4.50	4.58	7.22	9.86	9.94	10.45
-18.32						
-17.82						
-16.09						
-15.59	0.01	0.21	0.21	0.01	0.04	0.02
-15.51	0.13	4.36	4.36	0.13	0.84	0.41
-13.86	0.13	4.36	4.36	0.13	0.84	0.41
-12.21					0.04	
-12.13					0.96	
-10.24					0.04	
-10.16					0.68	
-8.82					0.04	
-8.74					0.96	
-6.85					0.04	
-6.77	0.11	3.51	3.51	0.11	0.68	
-5.44					0.04	
-5.36					0.97	
-3.46					0.04	
-3.38					0.68	
-2.05					0.04	
-1.97					0.96	
-0.08					0.04	
0.00	0.05	1.77	1.77	0.05	0.34	
0.67	0.05	1.77	1.77	0.05	0.34	
1.34					0.04	
1.42					0.96	
3.31					0.04	
3.39					0.68	
4.72					0.04	
4.80					0.97	
6.70					0.04	
6.78	0.11	3.51	3.51	0.11	0.68	
8.11					0.04	
8.19					0.96	
10.08					0.04	
10.16					0.68	
11.49					0.04	
11.57					0.97	
13.47					0.04	
13.55	0.13	4.36	4.36	0.13	0.84	0.41
15.20	0.13	4.36	4.36	0.13	0.84	0.41
16.85	0.01	0.21	0.21	0.01	0.04	0.02
16.93						
17.43						
19.68						
20.18						

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75	19.25
-18.32								
-17.82								
-16.09								
-15.59	0.04							
-15.51	0.87							
-13.86	0.87							
-12.21	0.04	0.01						
-12.13	1.00	0.15	4.97	4.99				
-10.24	0.04	0.01	0.21	0.21				
-10.16	0.71	0.11	3.52	3.54				
-8.82	0.04	0.01	0.21	0.21				
-8.74	1.00	0.15	4.97	4.99				
-6.85	0.04	0.01	0.21	0.21				
-6.77	0.70	0.11	3.50	3.51	0.11	2.78		
-5.44	0.04					0.17		
-5.36	1.01					3.97		
-3.46	0.04					0.17		
-3.38	0.70					2.78		
-2.05	0.04					0.17		
-1.97	1.00					3.95		
-0.08	0.04					0.17		
0.00	0.36	0.05	1.76	1.77	0.05	1.40		
0.67	0.36	0.05	1.76	1.77	0.05	1.40		
1.34	0.04					0.17		
1.42	1.00					3.95		
3.31	0.04					0.17		
3.39	0.70					2.78		
4.72	0.04					0.17		
4.80	1.01					3.97		
6.70	0.04					0.17		
6.78	0.70	0.11	3.50	3.51	0.11	2.78		
8.11	0.04	0.01	0.21	0.21				
8.19	1.00	0.15	4.97	4.99				
10.08	0.04	0.01	0.21	0.21				
10.16	0.70	0.11	3.50	3.51				
11.49	0.04	0.01	0.21	0.21				
11.57	1.01	0.15	5.00	5.02				
13.47	0.04	0.01						
13.55	0.87							
15.20	0.87							
16.85	0.04							
16.93								
17.43								
19.68								
20.18								

Product of Rectangle Area and Average Rectangle Temperature for PFE

AVERAGE ARGON TEMPERATURE: T = 579.81 °F

DISTANCE	0.00	0.88	1.76	2.64	2.72	3.48	3.73	4.50	4.58	7.22	9.86	9.94	10.45
-18.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-17.82	790.33	789.91	789.33	71.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-16.09	264.40	264.08	263.58	23.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-15.59	0.00	0.00	0.00	0.00	36.24	0.00	32.02	2.95	96.84	96.44	2.92	18.59	9.10
-15.51	0.00	0.00	0.00	0.00	756.91	0.00	696.94	67.90	2201.73	2139.94	63.78	401.80	193.76
-13.86	0.00	0.00	0.00	0.00	781.19	0.00	754.32	77.76	2539.07	2466.91	73.25	450.33	211.88
-12.21	0.00	0.00	0.00	0.00	38.63	0.00	37.87	0.00	0.00	0.00	0.00	23.35	0.00
-12.13	0.00	0.00	0.00	0.00	932.31	0.00	920.94	0.00	0.00	0.00	0.00	560.43	0.00
-10.24	0.00	0.00	0.00	0.00	40.28	0.00	40.07	0.00	0.00	0.00	0.00	24.09	0.00
-10.16	833.99	832.75	830.23	75.32	694.31	0.00	680.85	0.00	0.00	0.00	0.00	408.12	0.00
-8.82	0.00	0.00	0.00	0.00	42.62	0.00	41.21	0.00	0.00	0.00	0.00	24.64	0.00
-8.74	0.00	0.00	0.00	0.00	1017.55	0.00	985.86	0.00	0.00	0.00	0.00	592.53	0.00
-6.85	0.00	0.00	0.00	0.00	43.50	0.00	42.24	0.00	0.00	0.00	0.00	25.52	0.00
-6.77	0.00	0.00	0.00	0.00	727.99	0.00	717.00	74.59	2454.93	2423.98	72.69	437.01	0.00
-5.44	0.00	0.00	0.00	0.00	44.08	0.00	44.03	0.00	0.00	0.00	0.00	27.06	0.00
-5.36	0.00	0.00	0.00	0.00	1054.76	0.00	1054.83	0.00	0.00	0.00	0.00	651.18	0.00
-3.46	0.00	0.00	0.00	0.00	44.73	0.00	44.78	0.00	0.00	0.00	0.00	27.77	0.00
-3.38	887.47	887.01	886.11	80.50	750.11	0.00	746.89	0.00	0.00	0.00	0.00	463.67	0.00
-2.05	0.00	0.00	0.00	0.00	45.51	0.00	45.07	0.00	0.00	0.00	0.00	28.01	0.00
-1.97	0.00	0.00	0.00	0.00	1076.10	0.00	1065.73	0.00	0.00	0.00	0.00	662.01	0.00
-0.08	0.00	0.00	0.00	0.00	45.58	0.00	45.14	0.00	0.00	0.00	0.00	28.03	0.00
0.00	0.00	0.00	0.00	0.00	381.53	0.00	377.73	39.30	1294.35	1277.93	38.22	233.17	0.00
0.67	0.00	0.00	0.00	0.00	381.53	0.00	377.73	39.30	1294.35	1277.93	38.22	233.17	0.00
1.34	0.00	0.00	0.00	0.00	45.58	0.00	45.14	0.00	0.00	0.00	0.00	28.03	0.00
1.42	0.00	0.00	0.00	0.00	1076.11	0.00	1065.74	0.00	0.00	0.00	0.00	662.02	0.00
3.31	0.00	0.00	0.00	0.00	45.51	0.00	45.07	0.00	0.00	0.00	0.00	28.01	0.00
3.39	887.49	887.03	886.14	80.50	750.13	0.00	746.90	0.00	0.00	0.00	0.00	463.67	0.00
4.72	0.00	0.00	0.00	0.00	44.73	0.00	44.78	0.00	0.00	0.00	0.00	27.77	0.00
4.80	0.00	0.00	0.00	0.00	1054.80	0.00	1054.86	0.00	0.00	0.00	0.00	651.19	0.00
6.70	0.00	0.00	0.00	0.00	44.08	0.00	44.03	0.00	0.00	0.00	0.00	27.06	0.00
6.78	0.00	0.00	0.00	0.00	728.03	0.00	717.02	74.59	2455.00	2424.03	72.69	437.02	0.00
8.11	0.00	0.00	0.00	0.00	43.50	0.00	42.24	0.00	0.00	0.00	0.00	25.52	0.00
8.19	0.00	0.00	0.00	0.00	1017.64	0.00	985.92	0.00	0.00	0.00	0.00	592.55	0.00
10.08	0.00	0.00	0.00	0.00	42.62	0.00	41.22	0.00	0.00	0.00	0.00	24.65	0.00
10.16	827.89	826.65	824.15	74.77	689.22	0.00	675.83	0.00	0.00	0.00	0.00	405.09	0.00
11.49	0.00	0.00	0.00	0.00	40.29	0.00	40.08	0.00	0.00	0.00	0.00	24.09	0.00
11.57	0.00	0.00	0.00	0.00	937.44	0.00	925.92	0.00	0.00	0.00	0.00	563.41	0.00
13.47	0.00	0.00	0.00	0.00	38.64	0.00	37.87	0.00	0.00	0.00	0.00	23.36	0.00
13.55	0.00	0.00	0.00	0.00	781.48	0.00	754.46	77.77	2539.26	2467.01	73.25	450.34	211.88
15.20	0.00	0.00	0.00	0.00	757.30	0.00	697.08	67.90	2201.86	2139.98	63.78	401.80	193.76
16.85	0.00	0.00	0.00	0.00	36.26	0.00	32.02	2.95	96.84	96.44	2.92	18.59	9.10
16.93	266.09	265.76	265.26	24.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17.43	1034.93	1034.40	1033.67	93.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISTANCE	10.70	11.23	11.31	13.94	16.58	16.66	18.75	19.25
-18.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-17.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-16.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-15.59	19.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-15.51	402.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-13.86	421.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-12.21	21.44	2.95	0.00	0.00	0.00	0.00	0.00	0.00
-12.13	528.78	75.46	2384.23	2299.66	0.00	0.00	0.00	0.00
-10.24	23.05	3.40	106.49	98.89	0.00	0.00	0.00	0.00
-10.16	391.06	57.81	1810.75	1669.01	0.00	0.00	0.00	0.00
-8.82	23.63	3.50	109.63	100.38	0.00	0.00	0.00	0.00
-8.74	562.10	81.74	2591.66	2391.59	0.00	0.00	0.00	0.00
-6.85	23.92	3.41	109.48	102.23	0.00	0.00	0.00	0.00
-6.77	412.52	59.92	1939.16	1847.24	53.50	1329.31	0.00	0.00
-5.44	25.75	0.00	0.00	0.00	0.00	84.06	0.00	0.00
-5.36	623.16	0.00	0.00	0.00	0.00	2018.33	0.00	0.00
-3.46	26.71	0.00	0.00	0.00	0.00	85.81	0.00	0.00
-3.38	447.02	0.00	0.00	0.00	0.00	1432.39	0.00	0.00
-2.05	27.06	0.00	0.00	0.00	0.00	86.49	0.00	0.00
-1.97	639.98	0.00	0.00	0.00	0.00	2048.42	0.00	0.00
-0.08	27.11	0.00	0.00	0.00	0.00	86.91	0.00	0.00
0.00	227.40	33.64	1089.41	1054.75	31.22	726.22	0.00	0.00
0.67	227.40	33.64	1089.41	1054.76	31.22	726.22	0.00	0.00
1.34	27.11	0.00	0.00	0.00	0.00	86.91	0.00	0.00
1.42	639.99	0.00	0.00	0.00	0.00	2048.42	0.00	0.00
3.31	27.06	0.00	0.00	0.00	0.00	86.49	0.00	0.00
3.39	447.02	0.00	0.00	0.00	0.00	1432.39	0.00	0.00
4.72	26.71	0.00	0.00	0.00	0.00	85.81	0.00	0.00
4.80	623.16	0.00	0.00	0.00	0.00	2018.33	0.00	0.00
6.70	25.75	0.00	0.00	0.00	0.00	84.06	0.00	0.00
6.78	412.53	59.92	1939.17	1847.24	53.50	1329.31	0.00	0.00
8.11	23.92	3.41	109.48	102.23	0.00	0.00	0.00	0.00
8.19	562.11	81.75	2591.69	2391.59	0.00	0.00	0.00	0.00
10.08	23.63	3.50	109.63	100.38	0.00	0.00	0.00	0.00
10.16	388.15	57.38	1797.26	1656.56	0.00	0.00	0.00	0.00
11.49	23.05	3.40	106.49	98.89	0.00	0.00	0.00	0.00
11.57	531.59	75.86	2396.87	2311.84	0.00	0.00	0.00	0.00
13.47	21.44	2.95	0.00	0.00	0.00	0.00	0.00	0.00
13.55	421.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.20	402.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.85	19.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

A-4.0 CONTAINMENT

The containment evaluation of the IF-300 shipping cask is provided in Chapter 10.3.2 of Volume 1 [A-4.5.1-1]. The use of the Channelled BWR Fuel Basket has no physical effect on the cask containment boundary. However, the contents of the cask, 17 channelled BWR fuel assemblies, are different from the contents described in Volumes 1 and 2 [A-4.5.1-1]. This chapter documents the determination of the releasable source term within the IF-300 cask containing 17 irradiated BWR fuel assemblies with channels for the normal conditions of transport and the hypothetical accident conditions. These values are then compared to the source terms used to determine the leakage limits in Volumes 1 and 2 [A-4.5.1-1] and the effects of the revised source terms are assessed.

A-4.1 Containment Boundary

The IF-300 Cask containment boundary is its internal pressure retention boundary; that is, the inner shell assembly, head seal, drain and vent lines, drain and vent valves, and the cavity rupture disk. For purposes of this safety analysis, the containment boundary is identical to that described in Volumes 1 and 2 [A-4.5.1-1].

A-4.2 Requirements for Normal Conditions of Transport

The shipment of channeled BWR fuel assemblies presents a somewhat different radioactive source term for containment evaluation purposes than that of the Volume 1 and 2 analysis [A-4.5.1-1]. However, the structural evaluation and thermal evaluation of the IF-300 cask containment boundary documented in Volumes 1 and 2 [A-4.5.1-1] are still applicable.

A-4.2.1 Containment of Radioactive Material

1. Source Term

For both the normal conditions of transport and hypothetical accident conditions it is necessary to determine the releasable source term from activation products ("crud") adhering to the exterior surfaces of the fuel assemblies. The Volume 1 and 2 source term [A-4.5.1-1] is for PWR fuel assemblies, thus it is necessary to establish a new source term for channelled BWR fuel assemblies.

Based on recent DOE-sponsored source term work [A-4.5.1-3 & 6], fuel rod cladding crud data has been developed for two-year cooled BWR fuel. The

DOE work consisted of measurements of crud activity densities on PWR and BWR fuel rods from a number of reactors. The maximum measured spot values were then corrected to reflect the activity that would have been present at time of fuel discharge from the reactor for each of the measured radionuclides. The values reported in [A-4.5.1-3 and 6] for Zr-95 and Zn-65 are too low to be of concern and are not included in the evaluation. The maximum activity density for all measured BWR fuel assemblies for each remaining isotope is used to construct a "worst case" activity density, adjusted for a two year cooling time. This worst case density is conservatively assumed to occur on the entire BWR fuel assembly. In addition to the BWR fuel crud radionuclides included in [A-4.5.1-3] and [A-4.5.1-6], activity densities for Fe-55 and Ni-63 are obtained from [A-4.5.1-4]. The activity values reported in [A-4.5.1-4] are for PWR fuel assemblies. These values are divided by the area of a PWR fuel assembly, ignoring the hardware, to determine the activity densities. The activity density of Ni-63 on BWR fuel is assumed to be the same as on PWR fuel. For Fe-55, the crud activity density ratio of BWR to PWR fuel of Fe-59 is used [A-4.5.1-3], as both are elemental iron activation products. These activity densities are also adjusted for a two year cooling time.

The formation of crud deposits is associated with heated surfaces [A-4.5.1-7]. The fuel rod surface is heated to a much greater extent than the fuel channel, therefore it is expected that crud buildup on the channel will be minimal. Nonetheless it is conservatively assumed that the channel surfaces are crud contaminated to the same extent as the fuel rods. This assumption represents a 45% increase in the crud source term over the case where crud is assumed only on the fuel.

The results indicate that for 17 channeled BWR fuel assemblies the total crud inventory is 5,455 curies compared to 7,518 curies for 7 PWR assemblies as reported in [A-4.5.1-1].

2. A_2 Determination

The A_2 value for the crud mixture is calculated using the method based on the unity-rule [A-4.5.1-5]. The calculated A_2 equivalent for the channelled BWR fuel is 14.50 curies after 2 years cooling. This value is significantly less than the A_2 value of 162 curies calculated for the existing PWR basket in Volumes 1 and 2 [A-4.5.1-1].

PWR basket in Volumes 1 and 2 [A-4.5.1-1]. Therefore the leakage limits calculated in Volumes 1 and 2 are bounding for the 17 element Channelled BWR Fuel Basket. Table A-4.2-1 shows the A_2 calculations.

A-4.2.2 Pressurization of Containment Vessel

The pressure levels within the cask cavity under the normal conditions of transport and hypothetical accident conditions are determined in Sections A-3.4.4 and A-3.5.4, respectively. As discussed in Chapter A-3.0, the maximum pressures are below the rupture disk pressure of 350 psig. Therefore, the evaluation of the containment boundary for pressure documented in Volumes 1 and 2 [A-4.5.1-1] is unaffected.

A-4.2.3 Containment Criterion

As discussed in Section A-4.2.1 above, the calculated source term for the IF-300 shipping cask with 17 channelled BWR fuel elements is significantly less than the source term used to determine the leakage limits in Volumes 1 and 2 [A-4.5.1-1]. The test limits associated with those leakage limits are provided in Volumes 1 and 2 [A-4.5.1-1].

Table A-4.2-1

A2 Determination

Nuclide	A_2 [A-4.5.1-2]	Act. Fraction @ 2 yrs. in Crud mixture, f'	f'/A_2
Cr 51	600	1.3E-10	2.1E-13
Mn 54	20	5.88E-2	2.9E-3
Fe 55	1000	4.84E-1	4.8E-4
Co 58	20	2.5E-5	1.3E-6
Fe 59	10	5.6E-7	5.6E-8
Co 60	7	4.58E-1	6.54E-2
Ni 63	100	5.9E-4	5.9E-6
			6.88E-2

A_2-equivalent = 1/6.88E-2
= 14.50 ci

A-4.3 Containment Requirements for Hypothetical Accident Conditions

A-4.3.1 Fission Gas Products

A two-year cooled BWR fuel assembly contains 727 curies of Kr-85 [A-4.5.1-1]. Assuming that the Kr-85 from all 17 assemblies is released into the cask cavity free volume, the releasable inventory of this gas is 12,359 curies. The cavity pressure from fission gas release is evaluated in the thermal analysis described in Chapter A-3.0. The releasable inventory of Kr-85 used in the IF-300 cask leakage analysis documented in Volumes 1 and 2 [A-4.5.1-1] is 13,086 curies, which is greater than the available inventory when using the 17 element basket.

A-4.3.2 Containment of Radioactive Material

As discussed in Sections A-4.2.1 and A-4.3.1, the amount of radioactive material available for release using the 17 element Channelled BWR Fuel Basket is less than the quantities used to determine the cask containment criteria in Volumes 1 and 2 [A-4.5.1-1]. Therefore, the cask containment criteria of Volumes 1 and 2 is unaffected.

A-4.3.3 Containment Criterion

As discussed in Section A-4.3.2 above, the containment criteria for the IF-300 shipping cask documented in Volumes 1 and 2 [A-4.5.1-1] is bounding for the IF-300 cask with 17 channelled BWR fuel elements. The test limits associated with those leakage limits are provided in Volumes 1 and 2 [A-4.5.1-1].

A-4.4 Special Requirements

This section is not applicable to the IF-300 Cask.

A-4.5 Appendix

A-4.5.1 References

[1] Consolidated Safety Analysis Report for IF-300 Shipping Cask, NEDO-10084-3, General Electric Company, Docket No. 71-9001, May 1985.

[2] "Packaging and Transportation of Radioactive Materials," Title 10, Code of Federal Regulations, Part 71 (10CFR71), USNRC, 5/31/88.

[3] CONF-890631 - Vol 1, Proceedings - PATRAM '89, "An Estimate of the Contribution of 'Crud' to the Radioactive Source Term of a Spent Fuel Transport Cask," pp 171-178.

[4] EPRI-NP-2735, Expected Performance of Spent LWR Fuel Under Dry Storage Conditions, Battelle - Columbus, December 1982.

[5] CONF-830528 - Vol 1, Proceedings - PATRAM '83, "A Method for Determination of A_2 for a Mixture of Radionuclides," pp 365-368.

[6] Robert P. Sandoval, et al, Estimate of CRUD Contribution to Shipping Cask Containment Requirements, Sandia Report SAND88-1358 / TTC-0811, January 1991.

[7] EPRI NP-3789, Corrosion Product Buildup on LWR Fuel Rods, April 1985.

A-4.5.2 Reference Calculations

[A] "IF-300 Cask with Channelled BWR Fuel - Leakage Analysis," PNFSI Calculation No. 420-11.0208, Revision 0.

A-5.0 SHIELDING EVALUATION

The shielding analysis of the IF-300 Cask with the Channelled BWR Fuel Basket is described in this chapter. The Channelled BWR Fuel Basket contains 17 BWR intact fuel assemblies with a maximum burnup of 35,000 megawatt days per metric ton of initial heavy metal (MWD/MTIHM) [A-5.5.1-1]. The minimum cooling time for the fuel assemblies is three years. The initial U-235 enrichment range considered for 35,000 MWD/MTIHM is from 2.65% by weight (w/o) to 4.0 w/o. The results of the source term analysis show that the 2.65 w/o initial U-235 enrichment fuel with 35,000 MWD/MTIHM burnup and 3 year cooling time produced the neutron and gamma source strengths which enveloped all the BWR spent fuel assemblies considered in the aforementioned range. However, the Channelled BWR Fuel Basket design and associated shielding analysis is applicable to all BWR fuel with initial enrichments, burn-ups, and cooling times which result in source terms less than or equal to those documented in Section A-5.2. The design basis neutron and gamma source strengths and energy spectrums are given in Section A-5.2.

The IF-300 Cask with the Channelled BWR Fuel Basket provides adequate shielding to ensure compliance with the external dose rate requirements specified in Sections 47 and 51 of 10CFR Part 71 [A-5.5.1-2] and also 49CFR173.441 [A-5.5.1-3] for the fuel parameters stated above.

A-5.1 Discussion and Results

The IF-300 cask provides gamma and neutron radiation shielding. Gamma shielding in the IF-300 Cask body is provided by a depleted uranium shield and the stainless steel inner and outer shells which make up the cask wall. Neutron shielding is provided by a 50/50 volume percent ethylene glycol/water mixture contained within a stainless steel jacket surrounding the cylindrical portion of the cask body. Depleted uranium and stainless steel in the cask top and bottom ends also provide gamma shielding. In addition to the cask body shielding, the Channelled BWR Fuel Basket has depleted uranium shield blocks located at the top portion of basket to provide additional gamma shielding for activation products in the fuel assembly nozzle region. The IF-300 Cask has a corrugated surface on the cask side and axial fins at the cask ends which are conservatively neglected in the shielding evaluation.

The shielding requirements for the package for normal conditions of transport and hypothetical accident condition are determined by the following criteria:

Normal Conditions of Transport:	Maximum dose rate of 200 mrem per hour at any point in contact with the package, and 10 mrem/ hour at any point two (2) meters from the package (10CFR71.47(a) and (c) respectively) [A-5.5.1-2].
Hypothetical Accident Conditions:	Maximum dose rate of 1.0 rem/hour at any point one (1) meter from the cask (10CFR71.51(a)(2)) [A-5.5.1-2].

10CFR71.47 allows a contact dose rate on the package of 1000 millirem/hour during normal conditions of transport if the following conditions are met:

a) The shipment is made in a closed transport vehicle;
b) Provisions are made to secure the package so that its position within the vehicle remains fixed during transportation; and,
c) There are no loading and unloading operations between the beginning and end of transportation.

The IF-300 Cask satisfies all the above requirements per the Certificate of Compliance [A-5.5.1-1]. Therefore, the dose criteria for the IF-300 Cask with the Channelled BWR Fuel Basket is 1000 millirem/hour during normal conditions of transport on the surface of the IF-300 Cask and 200 millirem/hour on the surface of the closed transport vehicle. Also, the dose rate limit at 2 meters from the vertical planes represented by the outer lateral surfaces of the closed transport vehicle is 10.0 millirem/hour.

According to the Certificate of Compliance [A-5.5.1-1], the cask content shall be so limited that under normal conditions prior to transport, 62 times the neutron dose rate plus 6.3 times the gamma dose rate will not exceed 560 millirem/hour at a distance of 6 ft. from the side of the cask (10 ft. from the cask centerline).

During the hypothetical accident conditions defined in 10CFR71.73 (c), the cask is assumed to be separated from the skid. The corrugated barrel surrounding the neutron shielding cavity is assumed to be in place but ruptured due to the postulated cask drop. The cask cavity remains sealed due to the integrity of the closure, valves and rupture disk as documented in Volumes 1 and 2 [A-5.5.1-4].

For the shielding analysis during the hypothetical accident condition, neutron shielding (water) and the corrugated barrel surrounding the neutron shielding cavity is assumed to be lost.

Table A-5.1-1 summarizes the dose rates at the indicated dose points for IF-300 Cask with 17 BWR fuel assemblies in the Channelled BWR Fuel Basket. The IF-300 Cask with the Channelled BWR Fuel Basket meets all the above dose rate criteria for the design basis parameters as documented in this chapter.

Table A-5.1-1
Summary of Maximum Dose Rates
(mrem/hr)

Normal Conditions of Transport	Package Surface[2] (Peak) Side[1]	Top	Bottom	2 Meters from Vertical Plane of Vehicle Side[1]	Top	Bottom
Gamma	674.6	13.7	4.0	8.5	2.8	1.0
Neutron	44.9	44.9	74.1	0.9	1.8	3.0
Total	719.5	58.6	78.1	9.4	4.6	4.0
10CFR Part 71 Limit	1000	1000	1000	10	10	10

Hypothetical Accident Conditions	Package Surface (Peak) Side	Top	Bottom	1 Meter from Surface of Package Side	Top	Bottom
Gamma	674.6	13.7	4.0	18.1	13.7	4.0
Neutron	44.9	44.9	74.1	163.1	44.9	74.1
Total	719.5	58.6	78.1	181.2	58.6	78.1
10CFR Part 71 Limit	----	----	----	1000	1000	1000

Notes:

1. The maximum side surface dose rates during normal conditions of transport correspond to the cask upper head region (dose point R_0' in Figure A-5.3-1). The surface dose on the side surface of the cask at cask mid-plane is 3.0 and 9.8 millirem/hour neutron and gamma, respectively (dose point R_0 in Figure A-5.3-1).

2. The IF-300 cask is shipped within an aluminum enclosure which remains in place on the transport vehicle for the duration of transport. The maximum total dose rate on the surface of the aluminum enclosure is 142 mrem/hr. This meets the requirement of 200 mrem/hr on the accessible surface of the package.

A-5.2 Source Specification

The neutron and gamma radiological source strengths and gamma source spectrum were determined for the design basis channelled BWR fuel assembly using the ORIGEN2 computer code [A-5.5.1-5]. It is assumed that all the 17 BWR fuel assemblies have the maximum design basis neutron and gamma source strengths to calculate the maximum neutron and gamma source strength in the IF-300 Cask cavity with the Channelled BWR Fuel Basket.

To determine the material mass distribution of the design basis BWR fuel assembly, composite fuel assembly data is used. The assumed composite fuel assembly structural material mass distribution is given in Table A-5.2-1. The composition and impurity content of materials listed in Table A-5.2-1 are given in the ORIGEN2 input listing included in Section A-5.5.4.1. These composition and impurity contents are taken from the OCRWM data base [A-5.5.1-8]. The elemental compositions in Reference A-5.5.1-8 are determined from the American Society for Testing and Materials (ASTM) specifications and generally an upper limit for an impurity is used. The material weights for structural components of the composite fuel assembly are chosen such that they are bounding for the 7x7 and 8x8 General Electric (GE) BWR fuel assemblies [A-5.5.1-6], and the generic BWR fuel assembly structural material weights [A-5.5.1-7] which were used to calculate the neutron and gamma source strength in the OCRWM data base (DOE/RW-0184 [A-5.5.1-8]).

The weight of the fuel (UO_2) is based on the heavy metal (uranium) weight of 0.198 MTIHM per assembly [A-5.5.1-1]. This corresponds to a weight of 221.6 Kg of UO_2 in the fuel assembly which is considerably higher than the UO_2 weight given in References A-5.5.1-6, 7, and 9. The use of this higher weight of heavy metal is conservative since it will result in higher fission products in the fuel assembly.

Weights of the top and bottom end fittings include the weight of the tie plates and estimated weight of compression springs and fuel rod end caps. It is conservatively assumed that the compression springs and fuel rod end caps weight is not included in the top and bottom tie plate weights given in References A-5.5.1-6, 7, and 9. This assumption increases the activation product source terms in the fuel assembly nozzle regions.

The weight of the fuel assembly channels used in calculating the neutron and gamma source strengths is 45.5 Kg. This is also considerably higher than the nominal channel weight of 29.94 Kg given in Reference

A-5.5.1-9, and therefore increases the source term, which is conservative.

A-5.2.1 Gamma Source

The gamma source strength and energy spectrum for the design basis fuel assembly are calculated using the ORIGEN2 computer code [A-5.5.1-5]. The ORIGEN2 code computes the concentrations and radioactivity of fuel assemblies which undergo irradiation in a nuclear reactor and subsequent decay after removal from the reactor core. It has the ability to compute the isotopic fractions, radioactivity, decay thermal power, toxicity, neutron absorption, neutron emission, and photon emission for various isotopes in the fuel assembly.

ORIGEN2 is applicable to spent fuel shipping package analysis for developing neutron and gamma radioactive decay source strengths to be used in shielding analysis, and to provide thermal energy generation rates for use in thermal analysis. ORIGEN2 is an industry standard code which is supplied by Oak Ridge National Laboratory's Radiation Shielding Information Center (ORNL/RSIC).

The assumed fuel assembly structural material mass distribution input to the ORIGEN2 code analytical model is taken from Table A-5.2-1. In ORIGEN2, the power irradiation is performed for the fuel assembly materials in the active fuel region. The flux irradiation is performed for the fuel assembly materials in the top and bottom nozzle regions and gas plenum region. During power and flux irradiation cycles, 112.61 days per burnup cycle is used for incrementing burnups to keep the irradiation history smooth and reduce any oscillations in the ORIGEN2 code. The ORIGEN2 code produces computational errors if large burnup increments are used. A typical four region core with a typical 106 days of outage period is assumed similar to Reference A-5.5.1-8.

The flux factors for the top end fitting, bottom end fitting and gas plenum regions are taken from Reference A-5.5.1-10. The material composition including impurities is taken from Reference A-5.5.1-8. The cross-section library set for BWR fuel in ORIGEN2 is limited to 27,500 MWD/MTIHM burnup fuel [A-5.5.1-5]. Since there is no published cross-section library data set available for BWR fuel at 35,000 MWD/MTIHM burnup, the 27,500 MWD/MTIHM burnup library data set is also used for the 35,000 MWD/MTIHM burnup.

The Certificate of Compliance [A-5.5.1-1] specifies maximum initial U-235 enrichment for BWR fuel assemblies of 4.0 w/o. However, for the shielding analysis of the IF-300 Cask with the Channelled BWR Fuel Basket, a

conservative value of 2.65 w/o initial U-235 enrichment with 35,000 MWD/MTIHM burnup is used in calculating the neutron and gamma source terms. This is conservative since lower initial enrichment of U-235 in the fuel produces higher neutron source terms for the same burnup. Lower initial enrichment tends to increase the total neutron flux to maintain the same specific power. Increased neutron flux also causes an increase in the generation of activation products such as Co-60. However, generation of fission products (e.g., CS-137 and Ba 137m) is proportional to the fuel burnup, and is insensitive to the changes in enrichment. Use of minimum initial enrichment at 2.65 w/o with 35,000 MWD/MTIHM burnup generates conservative values for neutron source terms and activation product gamma sources in the nozzles and plenum region of the fuel assembly and has a negligible impact on the fission product source strength in the active fuel region of the fuel assembly.

It is assumed that the channels on the BWR fuel assemblies stay with the assemblies for their life, i.e., the channels are not reused. So the irradiation period and cycles for the channels are the same as that for the fuel assemblies. Hydrogen getters and burnable poison materials are not included in the source term calculations in the ORIGEN2 models and their shielding contribution is also neglected. This has a negligible impact on the overall dose rate results because of their relatively small weights compared to the other materials of the fuel assembly.

The ORIGEN2 input file for the design basis BWR fuel assembly is included in Section A-5.5.4. The fuel assembly is divided into TOP ZONE, PLENUM ZONE, IN-CORE ZONE, and BOTTOM ZONE during power and flux irradiation. After irradiation, these regions are decayed separately to give neutron and gamma source terms in all these regions separately. The WHOLE region in the ORIGEN2 analytical model is the sum of all the zones of the fuel assembly. The gamma source terms are calculated at the time of discharge from the core and then for decay periods of 2, 3, 4 and 5 years. For the analysis documented herein, a decay period of 3 years is used to calculate the design basis gamma source terms for the shielding analysis. Section A-5.5.4 contains the results of the ORIGEN2 analysis for a 3 year decay period.

Table A-5.2-2 shows the gamma source strength and the energy spectrum for the TOP ZONE, PLENUM ZONE, IN-CORE ZONE, BOTTOM ZONE, and WHOLE regions of the fuel assembly. These values are reported per BWR fuel assembly. To calculate the total gamma source in the cask internal cavity, these values are multiplied by 17 to account for the 17 fuel assemblies in the Channelled

BWR Fuel Basket. The total gamma source strength in the cask internal cavity is 7.9E+16 photons/sec (2.6E16 Mev/sec) with the energy spectrum shown in Tables A-5.2-2 and A-5.2-3. The end point energies for the gamma groups listed in Tables A-5.2-2 and A-5.2-3 are the same. These end point energies are the same as those of the ORIGEN2 code [A-5.5.1-5] and are listed in Table A-5.2-5.

The energy spectrum given in Table A-5.2-2 corresponds to the ORIGEN2 output. The energy ranges for the energy groups in the CASK cross-section library [A-5.5.1-11] used in the ANISN computer code [A-5.5.1-12] are slightly different. The shielding analysis is performed using the computer codes QAD-CGGP and ANISN with the CASK 18g-22n cross-section data set [A-5.5.1-13, 12, and 11, respectively]. ANISN/CASK is used to calculate gamma dose rates in the cask radial direction. QAD-CGGP is used to calculate the gamma dose rate in the cask axial direction. The ORIGEN2 gamma energy spectra is mapped in to the CASK gamma energy spectra in order to perform shielding analysis. The energy spectra from ORIGEN2 is directly used in QAD-CGGP models. Although both the CASK and ORIGEN2 energy spectra have 18 gamma energy groups, there is no 1-1 correspondence in energies. Mapping is done in such a way that the total gamma power (Mev/sec) is similar in both the energy spectra. Therefore the mapping process has minimal impact on the total calculated gamma dose rates. Table A-5.2-6 provides the CASK 18 gamma energy group structures used in ANISN/CASK calculations.

A-5.2.2 Neutron Source

The neutron source strength for the design basis fuel assembly is calculated in the same ORIGEN2 code analytical model used to calculate the gamma source strength as described in Section A-5.2.1. The assumptions are the same as those described in Section A-5.2.1.

The ORIGEN2 input file for the design basis BWR fuel assembly which is included in Section A-5.5.4 for the gamma source is also used for calculating the neutron source. The neutron source terms are calculated at the time of discharge from the core and then for decay periods of 2, 3, 4 and 5 years. For the analysis documented herein, a decay period of 3 years is used to calculate the design basis neutron source terms for shielding analysis. Section A-5.5.4 contains the results of the ORIGEN2 code for a 3 year decay period.

The isotope that forms the primary neutron source in 35,000 MWD/MTIHM burned fuel is Curium 244. This isotope decays by spontaneous fission and (α,n) reaction producing neutrons. Based on the results of the ORIGEN2 code, 96% of the neutrons are from spontaneous fission and the remaining 4% are from (α,n) reaction. Reference A-5.5.1-11 provides a typical $\Delta F(E)$ spectrum for fission neutrons, where $\Delta F(E)$ is the fraction of the fission neutrons generated in the E^{th} energy group. This fission spectrum is used for the neutrons in this analysis. Table A-5.2-4 shows the neutron source strength and the spectrum for the design basis fuel assembly. Since there are no neutron sources in the nozzles and plenum regions of the fuel assembly, all the neutrons are contained in the active fuel (IN-CORE) region of the fuel assembly. To calculate the total neutron sources in the cask internal cavity, these values are multiplied by 17 to account for 17 fuel assemblies in the Channelled BWR Fuel Basket. The total neutron source strength in the cask cavity is 1.9E+09 neutrons/sec with the energy spectrum given in Table A-5.2-4.

A-5.2.3 <u>Neutron and Gamma Sources with Axial Peaking Factor</u>

Figure A-5.2-1 shows the various instantaneous peaking factors for a typical fuel assembly [A-5.5.1-4]. As can be seen, the peak traverses the bundle as control rods are withdrawn (or the control blades inserted in the case of a BWR fuel assembly). This yields an end-of-life peak to average power (flux) ratio of just under 1.1. For a fuel assembly with a burnup of 35,000 MWD/MTIHM, the length of time a BWR fuel assembly is expected to be irradiated in the core will be greater than 930 days. For the radial (side) dose calculations, the assumption is made that the neutron and gamma source terms in each fuel assembly will be 1.2 times the average to account for axial peaking. This assumption is reasonable since the distribution of fission product sources three years after removal from the core will be influenced principally by the power (flux) distribution present at the end-of-life. This assumption is also conservative since an end-of-life peak to average ratio of just under 1.1 is predicted for a fuel assembly operating for 930 days which is smaller than the value of 1.2 used in this analysis.

To account for this axial peaking, the dose rates for radial (side) calculations given in Section A-5.4 are multiplied by 1.2, and the resulting values reported in Tables A-5.1-1 and A-5.4-5 for neutron and gamma dose rates for dose points R_0, R_1, and R_2 in Figure A-5.3-1.

Table A-5.2-1

Fuel Assembly Material Weights Used in ORIGEN2 Model for Neutron and Gamma Source Strengths

Fuel Assembly Zone/Component	Material	Weight Per Fuel Assembly (kg)	Reference
Fuel Zone (Active Fuel Region)			
- Cladding	Zircaloy-2	51.20	A-5.5.1-7
- Fuel Channels	Zircaloy-4	41.70	A-5.5.1-7
- Grid Spacers	Zircaloy-4	1.96	A-5.5.1-9
- Grid Spacer Springs	Inconel X-750	0.36	A-5.5.1-9
- Fuel	Uranium	198.00	A-5.5.1-1
Fuel Gas Plenum Zone			
- Cladding	Zircaloy-2	4.70	A-5.5.1-7
- Fuel Channel	Zircaloy-4	3.80	A-5.5.1-7
- Plenum Springs	SS-302	1.10	A-5.5.1-7
Top Nozzle Zone			
- Top End Fitting Including Compression Springs and End Caps	SS-304	3.21	A-5.5.1-9
Bottom Nozzle Zone			
- Bottom End Fitting Including End Caps	SS-304	6.01	A-5.5.1-7
- Expansion Spring	Inconel X-750	0.40	A-5.5.1-7

Table A-5.2-2

Design Basis Gamma Source Strength and Energy Spectrum
(Photon/sec)

GAMMA SOURCE ACTIV PROD+ACTINIDE+FISSION PROD, 3 YEAR DECAY						
E MEAN (MeV)	TOP (PER FA)	PLENUM (PER FA)	IN-CORE (PER FA)	BOTTOM (PER FA)	WHOLE (PER FA)	TOTAL (PER CASK)
0.01	5.0E+10	5.7E+10	1.2E+15	2.1E+11	1.2E+15	2.0E+16
0.03	7.6E+09	1.8E+11	2.9E+14	3.3E+10	2.9E+14	4.9E+15
0.04	4.3E+09	4.1E+10	2.9E+14	1.9E+10	2.9E+14	4.9E+15
0.06	4.8E+09	4.9E+09	2.4E+14	2.1E+10	2.4E+14	4.1E+15
0.09	1.9E+09	2.0E+09	1.7E+14	8.2E+09	1.7E+14	2.8E+15
0.13	7.3E+08	1.6E+09	1.8E+14	3.2E+09	1.8E+14	3.0E+15
0.23	2.4E+08	1.3E+10	1.4E+14	1.0E+09	1.4E+14	2.5E+15
0.38	6.7E+07	7.8E+10	8.7E+13	2.9E+08	8.7E+13	1.5E+15
0.58	9.1E+06	1.0E+11	1.5E+15	3.8E+07	1.5E+15	2.5E+16
0.85	4.2E+10	3.0E+10	4.4E+14	1.2E+11	4.4E+14	7.5E+15
1.25	1.6E+12	1.2E+12	1.0E+14	7.1E+12	1.1E+14	1.9E+15
1.75	9.7E+04	6.5E+04	4.1E+12	4.0E+05	4.1E+12	7.0E+13
2.25	8.7E+06	6.5E+06	3.7E+12	3.8E+07	3.7E+12	6.3E+13
2.75	2.7E+04	2.0E+04	1.1E+11	1.2E+05	1.1E+11	1.8E+12
3.50	1.1E-22	3.3E-15	1.3E+10	1.1E-13	1.3E+10	2.3E+11
5.00	0.0E+00	0.0E+00	4.7E+06	0.0E+00	4.7E+06	8.1E+07
7.00	0.0E+00	0.0E+00	5.5E+05	0.0E+00	5.5E+05	9.3E+06
9.50	0.0E+00	0.0E+00	6.3E+04	0.0E+00	6.3E+04	1.1E+06
SUM	1.8E+12	1.7E+12	4.6E+15	7.5E+12	4.6E+15	7.9E+16

Table A-5.2-3

Design Basis Gamma Source Strength and Energy Spectrum (Mev/sec)

GAMMA SOURCE ACTIV PROD+ACTINIDE+FISSION PROD, 3 YEAR DECAY						
E MEAN (MeV)	TOP (PER FA)	PLENUM (PER FA)	IN-CORE (PER FA)	BOTTOM (PER FA)	WHOLE (PER FA)	TOTAL (PER CASK)
0.01	5.0E+08	5.7E+08	1.2E+13	2.1E+09	1.2E+13	2.0E+14
0.03	1.9E+08	4.5E+09	7.2E+12	8.1E+08	7.2E+12	1.2E+14
0.04	1.6E+08	1.5E+09	1.1E+13	6.9E+08	1.1E+13	1.8E+14
0.06	2.8E+08	2.8E+08	1.4E+13	1.2E+09	1.4E+13	2.4E+14
0.09	1.6E+08	1.7E+08	1.4E+13	7.0E+08	1.4E+13	2.4E+14
0.13	9.1E+07	2.0E+08	2.2E+13	3.9E+08	2.2E+13	3.8E+14
0.23	5.4E+07	3.0E+09	3.3E+13	2.3E+08	3.3E+13	5.5E+14
0.38	2.5E+07	2.9E+10	3.3E+13	1.1E+08	3.3E+13	5.6E+14
0.58	5.2E+06	5.7E+10	8.6E+14	2.2E+07	8.6E+14	1.5E+16
0.85	3.5E+10	2.5E+10	3.7E+14	1.0E+11	3.7E+14	6.4E+15
1.25	2.1E+12	1.5E+12	1.3E+14	8.8E+12	1.4E+14	2.4E+15
1.75	1.7E+05	1.1E+05	7.2E+12	7.1E+05	7.2E+12	1.2E+14
2.25	2.0E+07	1.5E+07	8.3E+12	8.4E+07	8.3E+12	1.4E+14
2.75	7.4E+04	5.5E+04	2.9E+11	3.2E+05	2.9E+11	4.9E+12
3.50	3.9E-22	1.1E-14	4.7E+10	3.8E-13	4.7E+10	8.0E+11
5.00	0.0E+00	0.0E+00	2.4E+07	0.0E+00	2.4E+07	4.0E+08
7.00	0.0E+00	0.0E+00	3.8E+06	0.0E+00	3.8E+06	6.5E+07
9.50	0.0E+00	0.0E+00	6.0E+05	0.0E+00	6.0E+05	1.0E+07
SUM	2.1E+12	1.7E+12	1.5E+15	9.0E+12	1.5E+15	2.6E+16

Table A-5.2-4

Design Basis Neutron Source Strength and Energy Spectrum

CASK NEUTRON GROUP #	CASK NEUTRON GROUP UPPER ENERGY (Mev)	NEUTRON SOURCE SPECTRUM	FUEL ASSEM NEUTRON SOURCE STRENGTH (N/SEC/ASSEM) (3 YEAR DECAY)	CASK CAVITY NEUTRON SOURCE STRENGTH (N/SEC/CASK) (3 YEAR DECAY)
1	1.492E+01	4.653E-04	5.114E+04	8.693E+05
2	1.220E+01	1.883E-03	2.069E+05	3.518E+06
3	1.000E+01	5.756E-03	6.326E+05	1.075E+07
4	8.180E+00	1.924E-02	2.114E+06	3.595E+07
5	6.360E+00	4.000E-02	4.396E+06	7.473E+07
6	4.960E+00	5.174E-02	5.686E+06	9.667E+07
7	4.060E+00	1.094E-01	1.202E+07	2.044E+08
8	3.010E+00	8.804E-02	9.676E+06	1.645E+08
9	2.460E+00	2.088E-02	2.295E+06	3.901E+07
10	2.350E+00	1.156E-01	1.270E+07	2.160E+08
11	1.830E+00	2.089E-01	2.296E+07	3.903E+08
12	1.110E+00	1.920E-01	2.110E+07	3.587E+08
13	5.500E-01	1.327E-01	1.458E+07	2.479E+08
14	1.110E-01	1.345E-02	1.478E+06	2.513E+07
15	3.350E-03	0.000E+00	0.000E+00	0.000E+00
16	5.830E-04	0.000E+00	0.000E+00	0.000E+00
17	1.010E-04	0.000E+00	0.000E+00	0.000E+00
18	2.900E-05	0.000E+00	0.000E+00	0.000E+00
19	1.010E-05	0.000E+00	0.000E+00	0.000E+00
20	3.060E-06	0.000E+00	0.000E+00	0.000E+00
21	1.120E-06	0.000E+00	0.000E+00	0.000E+00
22	4.140E-07	0.000E+00	0.000E+00	0.000E+00
SUM		1.000E+00	1.099E+08	1.868E+09

Table A-5.2-5

End Point Energies from ORIGEN2

E mean ORIGEN2 (Mev)	End point Energies Lower Boundary (Mev)	End point Energies Upper Boundary (Mev)
0.010	0.0	0.020
0.025	0.02	0.030
0.0375	0.03	0.045
0.0575	0.045	0.070
0.085	0.070	0.100
0.125	0.10	0.150
0.225	0.15	0.300
0.375	0.30	0.450
0.575	0.45	0.700
0.850	0.70	1.000
1.250	1.00	1.500
1.750	1.50	2.000
2.250	2.00	2.500
2.750	2.50	3.000
3.500	3.00	4.000
5.000	4.00	6.000
7.000	6.00	8.000
9.500	8.00	11.00

Table A-5.2-6

End Point Energies from CASK

E mean CASK (Mev)	End point Energies Lower Boundary (Mev)	End point Energies Upper Boundary (Mev)
0.025	0.00	0.05
0.075	0.05	0.10
0.15	0.10	0.20
0.25	0.20	0.30
0.35	0.30	0.40
0.50	0.40	0.60
0.70	0.60	0.80
0.90	0.80	1.00
1.25	1.00	1.33
1.50	1.33	1.66
1.83	1.66	2.00
2.25	2.00	2.50
2.75	2.50	3.00
3.50	3.00	4.00
4.50	4.00	5.00
5.75	5.00	6.50
7.25	6.50	8.00
9.00	8.00	10.00

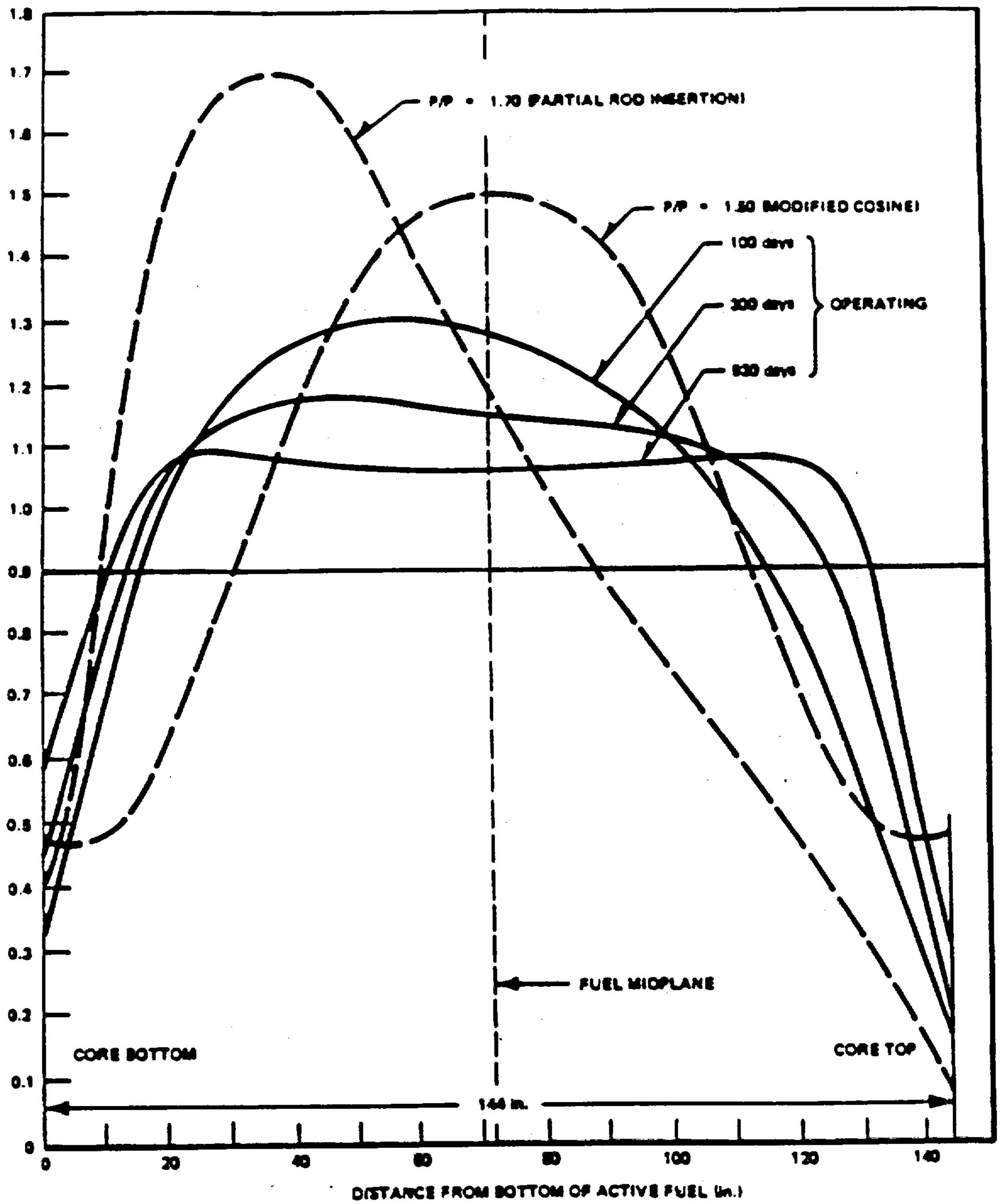


Figure A-5.2-1

Axial Local to Average Burnup and Instantaneous Power Comparisons

A-5.3 Model Specification

A shielding analysis is performed to confirm that the Channelled BWR Fuel Basket in the IF-300 Cask cavity with 17 design basis BWR fuel assemblies meets the shielding criteria specified in 10CFR71 [A-5.5.1-2], 49CFR173 [A-5.5.1-3], and the Certificate of Compliance of the IF-300 Cask [A-5.5.1-1]. Analytical models of the IF-300 Cask with the Channelled BWR Fuel Basket were developed to determine the dose rates at the critical locations around the IF-300 Cask. Computer codes ANISN [A-5.5.1-12] and QAD-CGGP [A-5.5.1-13] were used to determine the neutron and gamma dose rates as described in Section A-5.4.

A-5.3.1 Description of Radial and Axial Shielding Configuration

The radial and axial shielding configuration of the IF-300 Cask is the same as that described in the Certificate of Compliance [A-5.5.1-1] and Consolidated Safety Analysis Report [A-5.5.1-4]. The depleted uranium shield blocks on the top portion of the Channelled BWR Fuel Basket have the same thickness (one inch) as the existing design documented in Volumes 1 and 2 [A-5.5.1-4]. The arrangement of these shield blocks is such that streaming from the top nozzle region activation product sources is minimized.

Figure A-5.3-1 shows the axial and radial shielding configuration of the IF-300 Cask with the Channelled BWR Fuel Basket, including the depleted uranium shield blocks on the top portion of the basket. The portion of the IF-300 BWR Cask top head which is not covered by the depleted uranium shield blocks in the basket has the maximum dose on the cask surface (dose point R_0' in Figure A-5.3-1) during normal conditions of transport. This is because of the activation product sources in the nozzle region, the contribution from sources in the active fuel region, and the comparatively less shielding provided by cask head in that region. The results of the shielding analysis documented in Table A-5.2-1 show that the dose rates at this location on the cask surface are still below the 1,000 millirem per hour limit imposed by 10CFR71 [A-5.5.1-2]. Figure A-5.3-1 also shows the dose point locations considered to confirm that the applicable dose rate requirements [A-5.5.1-1, 2, and 3] are satisfied.

During the hypothetical accident conditions, the water in the neutron shield cavity is assumed to be lost and the corrugated barrel (water jacket) surrounding the neutron shielding cavity is assumed to be in place but ruptured due to the postulated cask drop. The cask cavity remains sealed due to the integrity of the closure, valves, and

rupture disk [A-5.5.1-4]. For the hypothetical accident conditions, water in the neutron shield cavity and corrugated barrel are removed from the analytical models. All the other shielding materials and cask surfaces are not affected by the accident conditions. The dose rates for the hypothetical accident conditions are within the limits imposed by 10CFR71 as shown in Table A-5.2-1.

A-5.3.2 Shield Regional Densities

This section gives the material densities (g/cm^3) and the atomic number densities (atoms/barn-cm) for constituent nuclides of all shielding materials used in the calculational models for the normal and accident conditions. Since the shielding contribution of the Channelled BWR Fuel Basket (specifically the basket spacer disks) is different for the cask radial and axial directions, two sets of densities are calculated. The first set is applicable for the radial (side) dose rate calculations in which shielding by the basket spacer disks is neglected. The second set is applicable for the axial dose rate calculations in which shielding by the basket spacer disks are included.

Shield regional densities for the fuel assembly active fuel, top nozzle and bottom nozzle regions are calculated based on conservative material weights in these regions. For dose rate calculations lighter material weights provide less shielding giving conservative dose rates. ORNL/TM-10902 [A-5.5.1-6] lists the material weights for various 7x7 and 8x8 GE BWR fuel assemblies. A review of this material weight data shows that the GE 8x8 retrofit pressurized assembly has relatively less shielding material in the active fuel zone and other parts of the assembly compared with other BWR fuel types. The material data for this assembly type is used to calculate the shield regional density of the active fuel, top nozzle and bottom nozzle regions of the design basis fuel assembly. Any shielding by the inconel (springs, etc.), burnable poisons and hydrogen getters in the fuel assembly is conservatively neglected. Also, any shielding provided by the neutron poison plates and support rods in the Channelled BWR Fuel Basket is conservatively neglected. Any impurities in the fuel, cladding or stainless steel is not included in calculating shield regional densities. Note that the material weights for fuel assembly components used for calculating neutron and gamma source strengths described in Sections A-5.2.1 and A-5.2.2 are higher than those used for calculating shield regional densities, providing a conservative basis for calculating source strengths.

The material weights in the various regions of the fuel assembly are homogenized using the diameter of the cask

inner cavity. The top nozzle region of the fuel assembly includes the portion of the fuel assembly above the active fuel length (i.e., upper gas plenum plus the top end fitting) including the channel. The bottom nozzle region of the fuel assembly includes the portion of the fuel assembly below the active fuel length of the fuel assembly including the channel.

1. Shield Regional Densities - Radial Direction

   The shield regional densities for calculating dose rates in the cask radial direction are calculated assuming no shielding contribution from the basket spacer disks. These densities are given in Table A-5.3-1.

2. Shield Regional Densities - Axial Direction

   The shield regional densities for calculating dose rates in the cask top and bottom axial directions are calculated using the shielding contribution of the basket spacer disks. There are seven 2 inch thick spacer disks in the active fuel region, one 2 inch thick spacer disk in the bottom nozzle region and one 2 inch thick spacer disk and a 0.75 inch thick top plate in the top nozzle region of the fuel assembly (Section A-1.3.2). Adding these weights in the respective regions, the shield regional densities used in the cask top and bottom axial direction dose rate calculations are given in Table A-5.3-2.

Table A-5.3-1

Radial Direction - Shield Regional Densities

Zone	Elements	Element Weight In Cask Cavity (Kg) [1]	Material Density (g/cm^3)	Atomic Number Density (atoms/barn-cm)
Active Fuel	Zircaloy	1243.6	0.458	3.027E-03
	Oxygen	418.2	0.154	5.792E-03
	U-235	122.2	0.045	1.159E-04
	U-238	2967.9	1.093	2.766E-03
Top Nozzle Region	Zircaloy	94.5	0.278	1.832E-03
	Iron	24.5	0.072	7.745E-04
	Chromium	6.5	0.019	2.203E-04
	Nickel	3.1	0.009	9.501E-05
Bottom Nozzle Region	Zircaloy	6.9	0.052	3.448E-04
	Iron	57.1	0.427	4.600E-03
	Chromium	15.1	0.113	1.308E-03
	Nickel	7.4	0.055	5.642E-04
Depleted Uranium (Gamma Shield)	U-235	N/A	0.041	1.061E-04
	U-238	N/A	18.780	4.753E-02
Cask Inner and Outer Shell	Chromium	N/A	1.525	1.767E-02
	Iron	N/A	5.761	6.213E-02
	Nickel	N/A	0.743	7.620E-03
Neutron Shield (Water)	Hydrogen	N/A	0.112	6.687E-02
	Oxygen	N/A	0.888	3.343E-02
Air (Surrounding Cask)	Nitrogen	N/A	0.00046	1.980E-05
	Oxygen	N/A	0.00014	5.28E0-06

Note:

1. N/A means not applicable. These elements are present in the outside regions of the cask inner cavity.

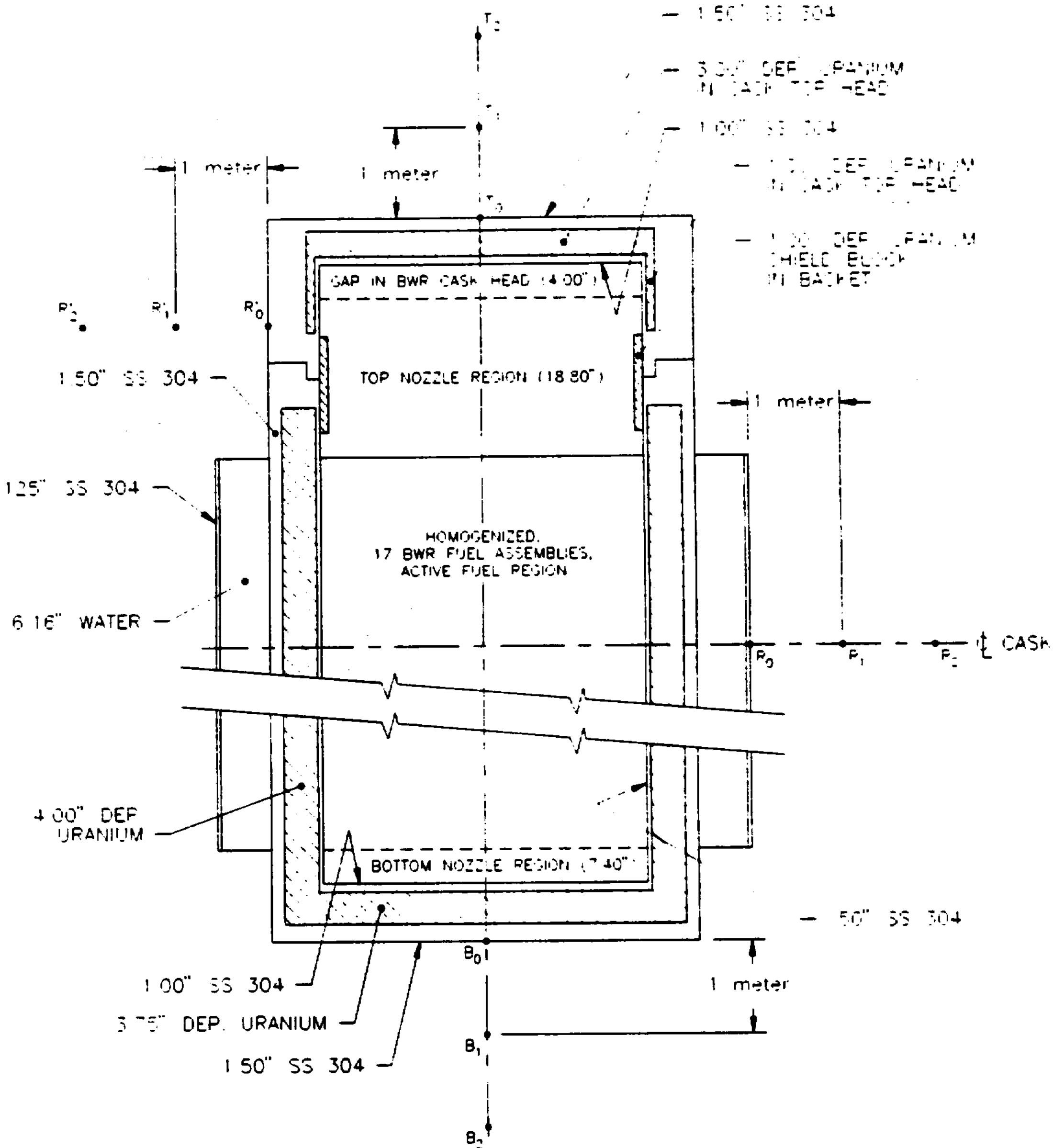
Table A-5.3-2

Axial Direction - Shield Regional Densities

Zone	Elements	Element Weight In Cask Cavity (Kg) [1]	Material Density (g/cm³)	Atomic Number Density (atoms/barn-cm)
Active Fuel	Zircaloy	1243.6	0.458	3.027E-03
	Oxygen	418.2	0.154	5.792E-03
	U-235	122.2	0.045	1.159E-04
	U-238	2967.9	1.093	2.766E-03
	Iron	646.3	0.238	2.570E-03
	Chromium	171.1	0.063	7.306E-04
	Nickel	84.2	0.031	3.150E-04
Top Nozzle Region	Zircaloy	94.5	0.278	1.832E-03
	Iron	151.6	0.446	4.807E-03
	Chromium	40.1	0.118	1.367E-03
	Nickel	19.7	0.058	5.895E-04
Bottom Nozzle Region	Zircaloy	6.9	0.052	3.448E-04
	Iron	149.4	1.118	1.206E-02
	Chromium	39.6	0.296	3.429E-03
	Nickel	19.2	0.144	1.479E-03
Depleted Uranium	U-235	N/A	0.041	1.061E-04
	U-238	N/A	18.78	4.753E-02
Cask Inner and Outer Shell	Chromium	N/A	1.525	1.767E-02
	Iron	N/A	5.761	6.213E-02
	Nickel	N/A	0.743	7.620E-03

Note:

1. N/A means not applicable. These elements are present in the outside regions of the cask inner cavity.

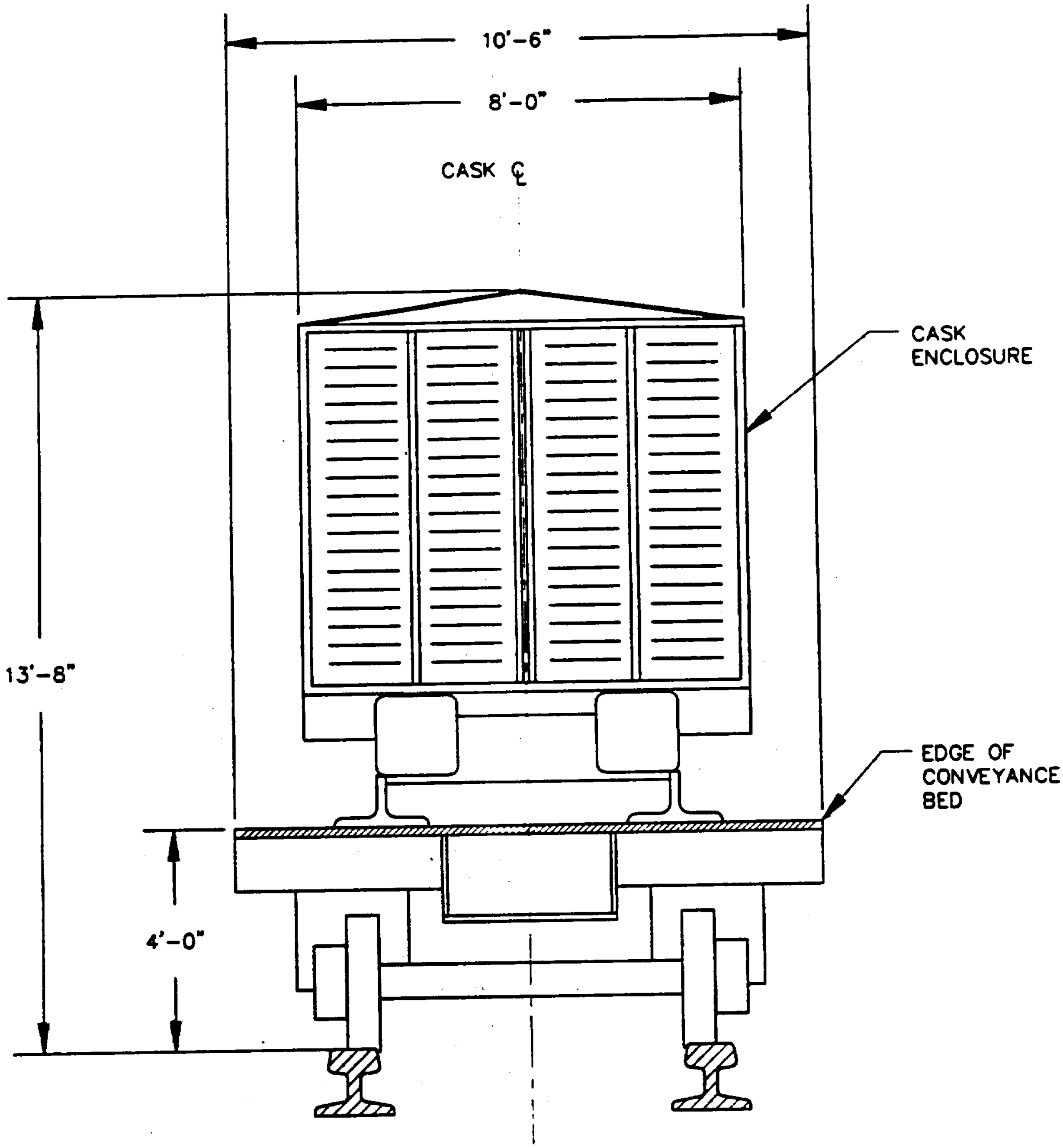


NOTES:

1 DOSE POINTS R_2, T_2, R'_2, AND B_2 ARE TWO METERS FROM THE VERTICAL PLANES REPRESENTED BY THE OUTER LATERAL SURFACE OF THE VEHICLE. THIS DISTANCE IS APPROXIMATELY 2.75 METERS FROM THE CASK SURFACE.

Figure A-5.3-1

Axial and Radial Shielding Configuration and Dose Point Locations on IF-300 Cask
(not to scale)



NOTE: THE DISTANCES FROM CASK ACTIVE FUEL REGION AND CASK TOP NOZZLE REGION SURFACES TO THE CASK ENCLOSURE CAN BE OBTAINED BY USING FIGURES 5.4-1 AND 5.4-2.

Figure A-5.3-2

Cask Enclosure Location

A-5.4 Shielding Evaluation

The neutron dose rates for the IF-300 Cask with Channelled BWR Fuel Basket were determined using the computer code ANISN/PC [A-5.5.1-12]. The gamma dose rates (primary and secondary gamma) were determined using the computer codes ANISN/PC and QAD-CGGP [A-5.5.1-13]. These codes are described below.

A-5.4.1 Dose Rates Using ANISN

The ANISN code [A-5.5.1-12] solves the one-dimensional Boltzmann transport equations for neutrons and/or gamma rays in a slab, spherical, or cylindrical geometry. The source may be fixed, fission, or a subcritical combination of the two. Cross-sections may be weighted using the space and energy dependent flux generated in solving the transport equation.

The ANISN code was designed to solve deep penetration problems in which angle-dependent spectra are calculated in detail. ANISN includes a technique for handling general anisotropic scattering, point-wise convergence criteria, and alternate step function difference equations that effectively remove the oscillating flux distributions sometimes found in discrete ordinates solutions. ANISN is an industry standard code available through ORNL/RSIC.

The cask geometry in the radial direction is cylindrical so radial shielding calculations are based on the cylindrical geometry model in ANISN. The radial dose rates from neutrons and gammas (both primary and secondary gamma) were determined at the locations shown in Figure A-5.3-1. To calculate the radial dose rates from the activation products in the top nozzle region, the cylindrical geometry model in ANISN is used. Since there are no neutron sources in the top nozzle region, only the gamma source is considered for calculating the radial dose rate from the activation products in the top nozzle region. The contribution from neutron and gamma sources in the active fuel region is then added to this dose rate to obtain the total dose rate on the side surface of the cask top head.

For the top and bottom axial directions of the IF-300 Cask with the Channelled BWR Fuel Basket, the slab geometry model in ANISN is used to calculate the neutron and secondary gamma (from (n,γ) reaction) dose rates.

The "CASK" 22 neutron - 18 gamma energy group coupled cross-section library data set [A-5.5.1-11] is used to supply microscopic cross-section data to the ANISN code. This cross-section data was designed for use in shipping

cask analysis by Oak Ridge National Laboratory. Since neutron and gamma energy groups are a coupled data set, both primary and secondary gamma dose rates are included in the results when this data set is used. The secondary fission sources in the fuel and uranium shield blocks are also included in the results. Third order scattering is used for both radial and axial models (i.e. P_3). S_8 angular quadrature set in cylindrical geometry is used in the ANISN radial models and S_{16} angular quadrature set in the slab geometry is used in the axial ANISN models [A-5.5.1-12]. These quadrature data sets are shown in Tables A-5.4-1 and A-5.4-2.

The material inside the active fuel region of the fuel assembly is homogenized to calculate the homogenized source region. The cask inner cavity diameter and the active fuel length of the fuel assembly are used to calculate the homogenized source region in the active fuel length of the fuel assembly. The material and the sources due to activation products inside the upper fuel gas plenum and upper end fitting and basket are combined together in a composite zone called "TOP NOZZLE REGION", to determine the dose on the cask surfaces due to activation products in the nozzle region. The "BOTTOM NOZZLE REGION" includes the bottom nozzle region of the fuel assembly and the portion of the basket below the active fuel region in the ANISN axial models.

In the ANISN models for the radial and axial direction of cask, the source and shield dimensions are input as zones divided into mesh intervals. Particle leakage due to finite transverse dimensions for planar and cylindrical geometries in ANISN [A-5.5.1-12] can be modeled by using buckling factors. In this shielding evaluation buckling correction is modeled by use of the ANISN input parameters BF, DY, and DZ in the 16* array. A particle flux is determined at each mesh interval for each neutron and gamma energy group. These fluxes are converted to dose rates using the flux-to-dose conversion factors [A-5.5.1-14] shown in Tables A-5.4-3 and A-5.4-4 for neutrons and gamma energy groups, respectively. The fuel assembly dimensions are from ORNL/TM-10902 [A-5.5.1-6] and the cask dimensions are from the IF-300 Cask Certificate of Compliance [A-5.5.1-1] and Volumes 1 and 2 [A-5.5.1-4].

The model shown in Figure A-5.4-1 is used to calculate the neutron and gamma dose rate on the surface of the cask and two meters from the surface in the cask radial direction at cask mid-plane. This corresponds to dose points R_0' and R_2 in Figure A-5.3-1. The model consists of concentric cylinders with dimensions from the Certificate of Compliance [A-5.5.1-1] and Volumes 1 and 2 [A-5.5.1-4]. The model consists of seven zones

describing the homogenized active fuel region inside the cask cavity and various cask shielding layers. In the ANISN model the height of the source region is used as the value of the ANISN parameter DY for buckling correction. This corresponds to 381 cm (the height of active fuel region in Figure A-5.4-1). This model is used to calculate the dose rates during normal conditions of transport.

During the hypothetical accident conditions, water in the neutron shield cavity is lost and the neutron shielding jacket (barrel) is ruptured due to a postulated cask drop. To calculate the dose rate on the cask surface and one meter from the cask surface, the same model as Figure A-5.4-1 is used except the neutron shield and shield jacket (barrel) are replaced by air. The one meter distance is taken from the outer surface of the cask structural shell.

The ANISN analytical model input files for the normal conditions of transport and hypothetical accident conditions are included in Section A-5.5.4. The dose rates for each mesh interval are included in Section A-5.5.4. The reported dose rates are without the axial peaking factor described in Section A-5.2.3. These dose rates are multiplied by the axial peaking factor of 1.2 to account for the variation in axial burnup. The final dose rate values are reported in Table A-5.4-5.

The gamma dose rate on the surface of the cask upper head region due to activation product sources in the TOP NOZZLE REGION of the cask are calculated using the ANISN model shown in Figure A-5.4-2. This corresponds to dose point R_0' in Figure A-5.3-1. The ANISN model contains Zone 1 as the TOP NOZZLE REGION which includes the activation product sources in the gas plenum and top end fitting regions of the fuel assembly. In the ANISN model the height of the cask top head region above the shield block is used as the value of the ANISN parameter DY for buckling correction. This corresponds to 23.14 cm. Zone 2 is the air gap between the IF-300 BWR cask upper head and the top nozzle region. Zones 3, 4, and 5 are the shield layers in the BWR cask upper head. The contribution from the neutron sources in the active fuel region is calculated using an analytical model similar to that used for the cask top axial direction described in Section A-5.4.1.2. The contribution due to gamma sources in the active fuel region is calculated using the computer code QAD-CGGP as described in Section A-5.4.2. These dose rates are added to the dose rate due to activation products in the TOP NOZZLE REGION to calculate the total dose at dose point R_0' in Figure A-5.3-1.

To calculate the dose at six feet from the upper head surface and two meters from the transport vehicle outer edge at this location, attenuation factors are developed as described in Section A-5.5.2. These attenuation factors are used to confirm that the 10CFR71 dose rate limits are satisfied. The results are summarized in Table A-5.4-5.

1. ANISN Models for Axial Dose Rate Calculation

Figures A-5.4-3 and A-5.4-4 show the ANISN models used for the axial dose rates due to neutrons and secondary gammas on the cask surface in the top and bottom axial directions respectively. These models are used to calculate the neutron dose rates on the cask surfaces in the axial directions. These models are also used to calculate the secondary gamma dose rates in the cask axial directions. In the ANISN models used to calculate neutron dose rates in the cask axial directions (Figures A-5.4-3 and A-5.4-4), the width of the source region is used for the value of parameters DY and DZ for buckling correction. This corresponds to 95.25 cm (the diameter of cask inner cavity in Figures A-5.4-1 and A-5.4-2). The primary gamma dose rates in the cask axial directions are calculated separately using computer code QAD-CGGP [A-5.5.1-12] as described in Section A-5.4.2. The total dose on the cask surfaces in the axial direction is then the sum of primary gamma, secondary gamma, and neutron dose rates at these locations.

The ANISN analytical model input files for calculating the top and bottom axial dose on the cask surfaces are included in Section A-5.5.4. The dose rates for each mesh interval are also included in Section A-5.5.4.

Figure A-5.3-2 shows the dimensions and location of the aluminum enclosure relative to the cask and conveyance bed. The attenuation factors for the dose point on the surface of the aluminum enclosure due to sources in the top nozzle and active fuel region of the fuel assembly are calculated using the same method as that of Section A-5.5.3.1. These attenuation factors are used to confirm that the 10CFR71 dose rate limits are satisfied. The results show that the dose rate at the surface of the aluminum enclosure does not exceed 200 mrem/hr. The results are summarized in Table A-5.4-5.

To calculate the dose at two meters from the outer edge of transport vehicle, attenuation factors are

developed as described in Section A-5.5.3. These attenuation factors are used to confirm that the 10CFR71 dose rate limits are satisfied. The results are summarized in Table A-5.4-5.

The neutron sources in the active fuel region contribute to the total dose rate on the side surface of cask upper head region (dose point R_0' in Figure A-5.3-1). This neutron dose rate is calculated using an analytical model similar to Figure A-5.4-3 with the CASK TOP HEAD zones replaced by zones 3, 4, and 5 in Figure A-5.4-2. The results show that the neutron dose at dose point R_0' is bounded by the neutron dose at dose point T_o in Figure A-5.3-1. Therefore, the neutron dose at dose point T_o is used for the dose at point R_0'.

A-5.4.2 Dose Rates Using QAD-CGGP

Computer code QAD-CGGP [A-5.5.1-13] is used to calculate the gamma dose rates (primary gamma's only) in the top and bottom axial directions of the IF-300 Cask with Channelled BWR Fuel Basket.

QAD-CGGP [A-5.5.1-13] is a point-kernel shielding code that uses three dimensional geometry to define the source and shielding configurations. The code allows the combination of geometric shapes by "AND/OR" operators into zones which can then be assigned an amalgamation of elemental densities. Mass attenuation and buildup factors are obtained from QAD-CGGP's internal library. Since the majority of the gamma shielding is provided by depleted uranium, uranium Geometric-Progression (G-P) buildup factors are selected. The gamma energy spectrum obtained from the results of ORIGEN2 [A-5.5.1-5] codes (Section A-5.2.1) is used to determine the gamma dose rates.

The QAD-CGGP model for the axial dose calculations consists of eight zones made up of eight bodies. The origin of the coordinate system is chosen to be the center of the active fuel region with the Z axis directed toward the cask top. The bodies making up the IF-300 Cask models are all right circular cylinders (RCC), while the body defining the "universe" is a rectangular parallel-piped (RPP). The QAD-CGGP bodies making up the IF-300 Cask model are shown in Figure A-5.4-5.

The following bodies make up the IF-300 Cask QAD-CGGP model:

1. Active Fuel Region: The active fuel region is assumed to be 150 inches long [A-5.5.1-6], and homogenized using the inside diameter of the IF-300 Cask inner cavity.

2. Top Nozzle Region: The top nozzle region is assumed to be 18.775 inches long [A-5.5.1-6] and homogenized using the inside diameter of the cask inner cavity. The top nozzle region includes the upper gas plenum and top end fitting regions of the fuel assembly.

3. Air Gap Region: The air gap region length is equal to the cask cavity length less the fuel assembly length. The cask cavity length is 180.25 inches [A-5.5.1-1] and the fuel assembly length is 176.16 inches [A-5.5.1-6].

4. Bottom Nozzle Region: The bottom nozzle region is assumed to be 7.385 inches long [A-5.5.1-6] and homogenized using the inside diameter of the cask cavity.

5. Inner Shell Region: Body 5 defines the outer surface of the cask inner shell. The inner shell is stainless steel 304, 0.5 inch thick in the cask radial direction, 1.0 inch thick at the top and 1.25 inch thick at the cask bottom direction [A-5.5.1-1].

6. Gamma Shield Region: Body 6 defines the outer surface of the cask gamma shield. The gamma shield is depleted uranium, 4.0 inches thick in the cask radial direction, 3.0 inches thick at the cask top and 3.75 inches thick at the cask bottom direction [A-5.5.1-1].

7. Outer Shell: Body 7 defines the outer surface of the cask outer shell. The shell is stainless steel 304, 1.5 inch thick in the cask radial direction and at the top and bottom direction of the cask [A-5.5.1-1].

8. Universe: Body 8 defines the ambient air surrounding the cask in which dose points are located.

The QAD-CGGP zones are defined as follows: Zone 1 (active fuel) includes all of Body 1. Zone 2 (top nozzle) includes all of Body 2. Zone 3 (air gap) includes all of Body 3. Zone 4 (bottom nozzle) includes all of Body 4. Zone 5 (inner shell) includes everything inside Body 5 that is outside of Bodies 1 through 4. Zone 6 (gamma shield) includes everything inside Body 6 that is outside of Body 5. Zone 7 (outer shell) includes

everything inside Body 7 that is outside of Body 6. Zone 8 (universe) includes everything inside Body 8 that is outside of Body 7. The QAD-CGGP zones are shown in Figure A-5.4-6.

Three QAD-CGGP runs are made assuming sources in the top nozzle region, sources in active fuel region and sources in the bottom nozzle region. The results of these runs are then summed to give a total gamma dose rate due to primary gammas at each dose point locations. The dose point locations are shown in Table A-5.1-1 and Figure A-5.3-1. The secondary gamma dose rates are calculated in Section A-5.4.1.

The flux-to-dose conversion factors are the same as those used in Section A-5.4.1. The gamma sources in the active fuel region and activation product sources in the top and bottom nozzle regions are taken from Section A-5.2.1. The top nozzle region source includes the sources due to the upper gas plenum and the top end fitting (top nozzle) regions. The source strengths due to gamma energy groups between the range of 0.37 to 3.5 Mev mean energies were considered in this analysis. The contribution to the total gamma dose rate due to gamma's outside of this energy range were found to be negligible.

The gamma source strengths for the sources in the active fuel, top nozzle and bottom nozzle regions along with the corresponding flux-to-dose conversion factors are shown in Table A-5.4-6.

The QAD-CGGP analytical model input files with the sources in these regions are included in Section A-5.5.4. The results of the QAD-CGGP computer runs for the detector locations shown in Table A-5.1-1 and Figure A-5.3-1 are also included in Section A-5.5.4 for the sources in the top and bottom nozzle regions. Table A-5.4-7 gives the results of the QAD-CGGP runs.

The gamma sources in active fuel region contribute to the total dose rate on the side surface of cask upper head region (dose point R_0' in Figure A-5.3-1). This gamma dose rate is calculated using a QAD-CGGP analytical model similar to Figure A-5.4-5 with the inner shell, gamma shield and outer shell regions at the cask top axial directions replaced by zones 3, 4, and 5 in Figure A-5.4-2. The air gap region is deleted from the model and iron buildup factors are used. The results show that the gamma dose rate at dose point R_0' from sources in the active fuel region is 144 millirem/hour.

Table A-5.4-1

Cylindrical Geometry S_8 Quadrature Set
[A-5.5.1-12]

Quadrature Order		Direction Cosine (μm)	Direction Weight (Wm)
S_8	1.	-.975900	.00
	2.	-.9511897	.0604938
	3.	-.7867958	.0453704
	4.	-.5773503	.0453704
	5.	-.2182179	.0604938
	6.	+.2182179	.0604938
	7.	+.5773503	.0453704
	8.	+.7867958	.0453704
	9.	+.9511897	.0604938
	10.	-.8164965	.00
	11.	-.7867958	.0453704
	12.	-.5773503	.0462962
	13.	-.2182179	.0453704
	14.	+.2182179	.0453704
	15.	+.5773503	.0462962
	16.	+.7867958	.0453704
	17.	-.6172134	.00
	18.	-.5773503	.0453704
	19.	-.2182179	.0453704
	20.	+.2182179	.0453704
	21.	+.5773503	.0453704
	22.	-.3086067	.00
	23.	-.2182179	.0604938
	24.	+.2182179	.0604938

Table A-5.4-2

Planer Geometry S_{16} Quadrature Set
[A-5.5.1-12]

Quadrature Order		Direction Cosine (μm)	Direction Weight (Wm)
S_{16}	1.	-.9902984	.00
	2.	-.9805009	.0244936
	3.	-.9092855	.0413296
	4.	-.8319966	.0392569
	5.	-.7467506	.0400796
	6.	-.6504264	.0643754
	7.	-.5370966	.0442097
	8.	-.3922893	.1090850
	9.	-.1389568	.1371702
	10.	.1389568	.1371702
	11.	.3922893	.1090850
	12.	.5370966	.0442097
	13.	.6504264	.0643754
	14.	.7467506	.0400796
	15.	.8319966	.0392569
	16.	.9092855	.0413296
	17.	.9805009	.0244936

Table A-5.4-3

Neutron Flux-to-Dose Conversion Factors

Upper Energy Level[A-5.5.1-11] (MeV)	Flux-to-Dose Conversion Factor[A-5.5.1-14] (mrem/hr per neutron/cm^2-sec)
1.49 E+1	1.9449 E-1
1.22 E+1	1.5971 E-1
1.00 E+1	1.4706 E-1
8.18 E+0	1.4773 E-1
6.36 E+0	1.5339 E-1
4.96 E+0	1.5062 E-1
4.06 E+0	1.3892 E-1
3.01 E+0	1.2843 E-1
2.46 E+0	1.2527 E-1
2.35 E+0	1.2632 E-1
1.83 E+0	1.2894 E-1
1.11 E+0	1.1685 E-1
5.50 E-1	6.5209 E-2
1.11 E-1	9.1878 E-3
3.35 E-3	3.7134 E-3
5.83 E-4	4.0086 E-3
1.01 E-4	4.2946 E-3
2.90 E-4	4.4761 E-3
1.01 E-5	4.5673 E-3
3.06 E-6	4.5355 E-3
1.12 E-6	4.3701 E-3
4.14 E-7	3.7142 E-3
1.00 E-8	-

Table A-5.4-4

Gamma Flux-to-Dose Conversion Factors

Upper Energy Level[A-5.5.1-11] (MeV)	Flux-to-Dose Conversion Factor[A-5.5.1-14] (mrem/hr per photon/cm^2-sec)
10.00	8.7716 E-3
8.00	7.4785 E-3
6.50	6.3748 E-3
5.00	5.4136 E-3
4.00	4.6221 E-3
3.00	3.9596 E-3
2.50	3.4686 E-3
2.00	3.0142 E-3
1.66	2.6276 E-3
1.33	2.2051 E-3
1.00	1.8326 E-3
0.80	1.5228 E-3
0.60	1.1725 E-3
0.40	8.7594 E-4
0.30	6.3061 E-4
0.20	3.8338 E-4
0.10	2.6693 E-4
0.05	9.3477 E-4

Table A-5.4-5

Neutron and Secondary Gamma Dose Rates Using ANISN (mrem/hour)

Cask Location	Dose Point Distance from Surface (m)	Neutron Dose Rate	Secondary Gamma Dose Rate	Total Gamma (Primary + Secondary) Dose Rate	Total (Neutron + Gamma) Dose Rate
Radial Cask Centerline (Normal Condition)	0.0	3.03	(1)	9.77	12.80
	1.83	0.76	(1)	2.50	3.26
	2.0	0.71	(1)	2.33	3.04
Radial Cask Top Nozzle - Act. Prod. Sources in Nozzle	0.0	0.0	0.0	530.80	530.80
	1.83	0.0	0.0	11.27	11.27
	2.0 (2)	0.0	0.0	5.53	5.53
Radial Cask Top Nozzle - Sources in Active Fuel	0.0	44.93	(1)	143.80	188.73
	1.83	1.77 (4)	(1)	5.69 (4)	7.46
	2.0 (2)	0.92 (5)	(1)	2.97 (5)	3.89
Radial Cask Top Nozzle - Total Due to All Sources	0.0	44.93	(1)	674.60	719.53
	1.83	1.77	(1)	16.96	18.73
	2.0 (2)	0.92	(1)	8.50	9.42
Radial Cask Aluminum Enclosure Top Noz Contribution	0.0	9.84	(1)	126.78	136.62
Radial Cask Aluminum Enclosure Act.Fuel Contribution	0.0	1.36	(1)	4.41	5.77
Radial Cask Aluminum Enclosure Total due to all Sources	0.0	11.20	(1)	131.19	142.39
Axial - Top (3)	0.0	44.93	0.10	13.70	58.63
	2.0 (2)	1.80	0.10	2.82	4.62
Axial - Bottom (3)	0.0	74.11	0.13	3.96	78.07
	2.0 (2)	2.97	0.13	0.95	3.92
Radial Cask (6) Centerline Location Total due to all sources	0.0	448.80	(1)	13.63	462.43
Radial Cask (6) Top Nozzle Location Total due to all sources	0.0	44.93	(1)	674.60	719.53
Radial Cask (6) Centerline Location Act.Fuel Contribution	1.0	162.07	(1)	5.37	167.44

Table A-5.4-5

Neutron and Secondary Gamma Dose Rates
Using ANISN (mrem/hour)
(Concluded)

Cask Location	Dose Point Distance from Surface (m)	Neutron Dose Rate	Secondary Gamma Dose Rate	Total Gamma (Primary + Secondary) Dose Rate	Total (Neutron + Gamma) Dose Rate
Radial Cask(6) Centerline Location Top Noz Contribution	1.0	0.99	(1)	12.73	13.72
Radial Cask(6) Centerline Location Total due to all Sources	1.0	163.06	(1)	18.10	181.16
Radial Cask(6) Top Nozzle Location Top Noz Contribution	1.0	4.04	(1)	52.11	56.15
Radial Cask(6) Top Nozzle Location Act.Fuel Contribution	1.0	110.40	(1)	3.36	113.76
Radial Cask(6) Top Nozzle Location Total due to all Sources	1.0	114.44	(1)	55.47	169.91

Notes:

1. Calculated internally by ANISN and included in the total gamma dose rate.
2. The 2 meter distance is from the edge of the transport vehicle.
3. The primary gamma dose rate values are from Table A-5.4-7.
4. This includes a contribution due to the active fuel portion of cask surface.
5. This includes a contribution due to the active fuel portion of the cask surface.
6. Accident condition dose rates.

Table A-5.4-6

Gamma Source Strength, Energy Spectrum and Flux-to-Dose Conversion Factors Used in QAD-CGGP Models

	Gamma Source Strength (photons/sec-cm^3)			
E mean (Mev)	Active Fuel Region Sources (1)	Top Nozzle Region Sources (2)	Bottom Nozzle Region Sources (3)	Flux-to-Dose Conversion Factors mrem/hr per Photons/cm^2-sec
0.37	5.5E+8	3.9E+6	3.7E+4	0.0008759
0.57	9.4E+9	5.0E+6	4.9E+3	0.0011725
0.85	2.8E+9	3.9E+6	1.5E+7	0.001833
1.2	6.4E+8	1.4E+8	9.0E+8	0.002205
1.8	2.6E+7	8.1E+0	5.1E+1	0.003019
2.2	2.3E+7	7.6E+2	4.8E+3	0.003469
2.8	6.6E+5	2.4E+0	1.5E+1	0.003960
3.5	8.4E+4	~0.0	~0.0	0.004622

Notes:

1. The volume of active fuel region used to calculate the source strength = $\pi R^2 h = \pi(47.63)^2 \times (381) = 2.715E+6\ cm^3$

2. The volume of top nozzle region used to calculate the source strength = $\pi R^2 h = \pi(47.63)^2 \times (47.69) = 3.399E+5\ cm^3$

3. The volume of bottom nozzle region used to calculate the source strength = $\pi R^2 h = \pi(47.63)^2 \times (18.76) = 1.337E+5\ cm^3$

Table A-5.4-7

Primary Gamma Dose Rates in IF-300 Cask Axial Directions Using QAD-CGGP (Mrem/hour)

Cask Axial Location	Dose Point Distance From Surface (m)	Dose Due To Sources in Top Nozzle Region	Dose Due To Sources in Active Fuel Region	Dose Due To Sources in Bottom Nozzle Region	Total Dose At Dose Point
Top	0.0	6.9	6.7	0.0	13.6
	2.0	1.4	1.3	0.0	2.7
Bottom	0.0	0.0	1.9	2.0	3.8
	2.0	0.0	0.4	0.4	0.8

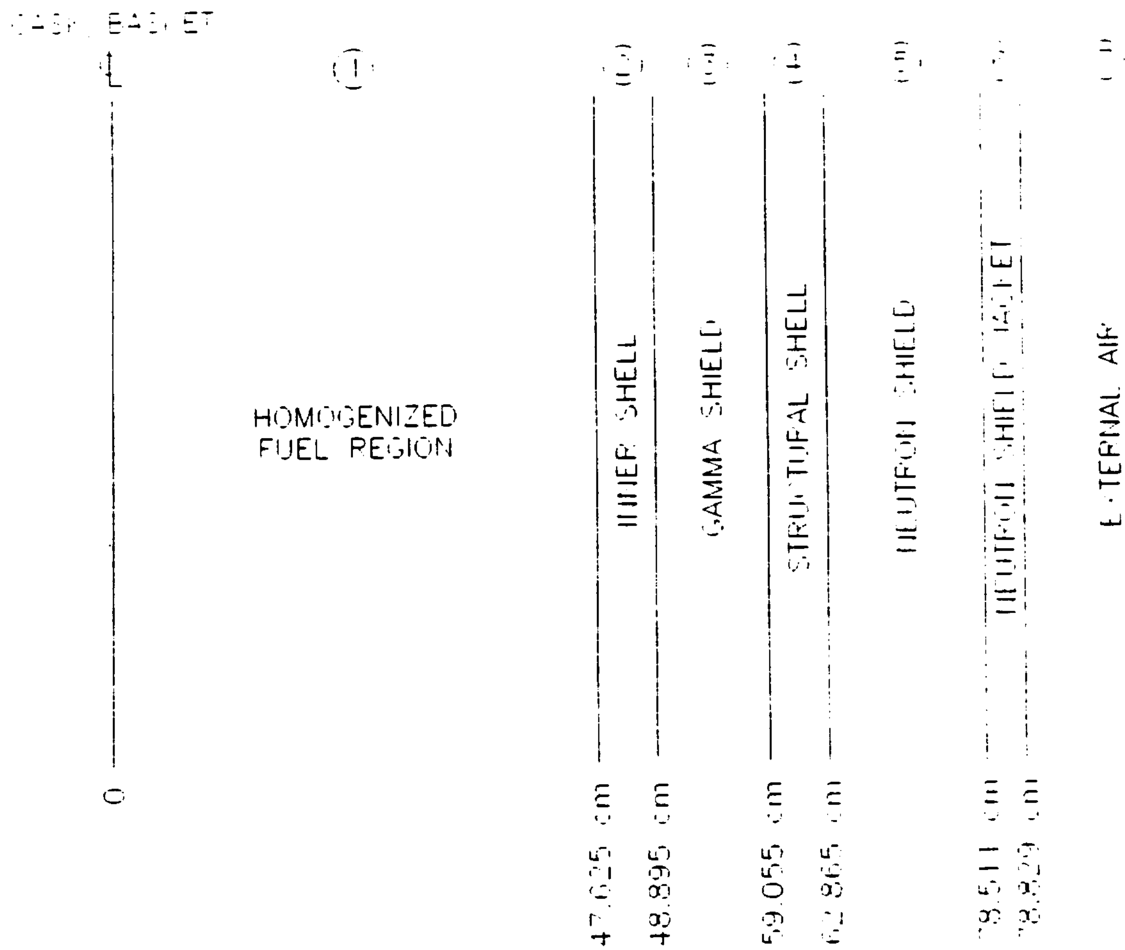


Figure A-5.4-1

<u>ANISN Model for Radial Case</u>

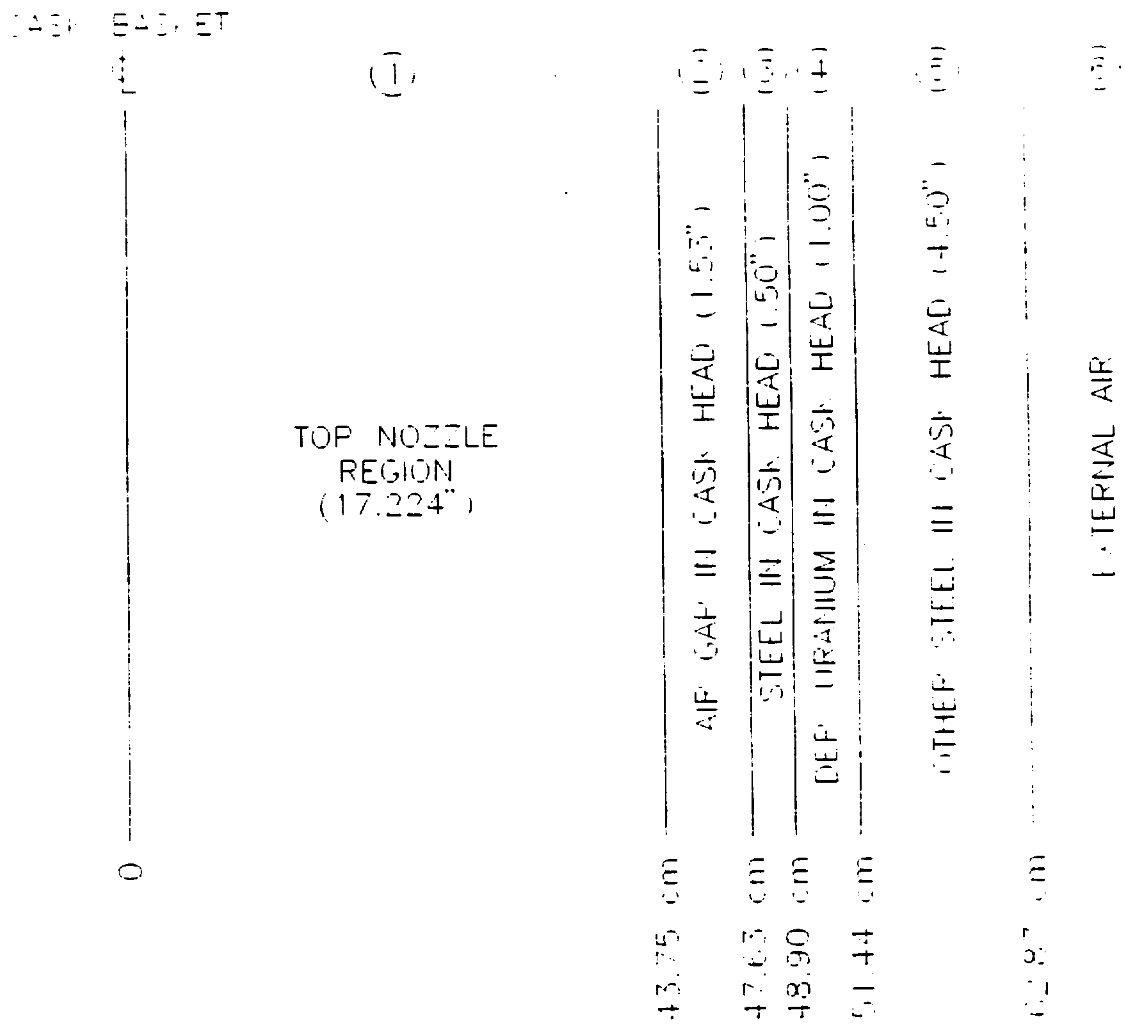


Figure A-5.4-2

ANISN Model of Cask Head Region

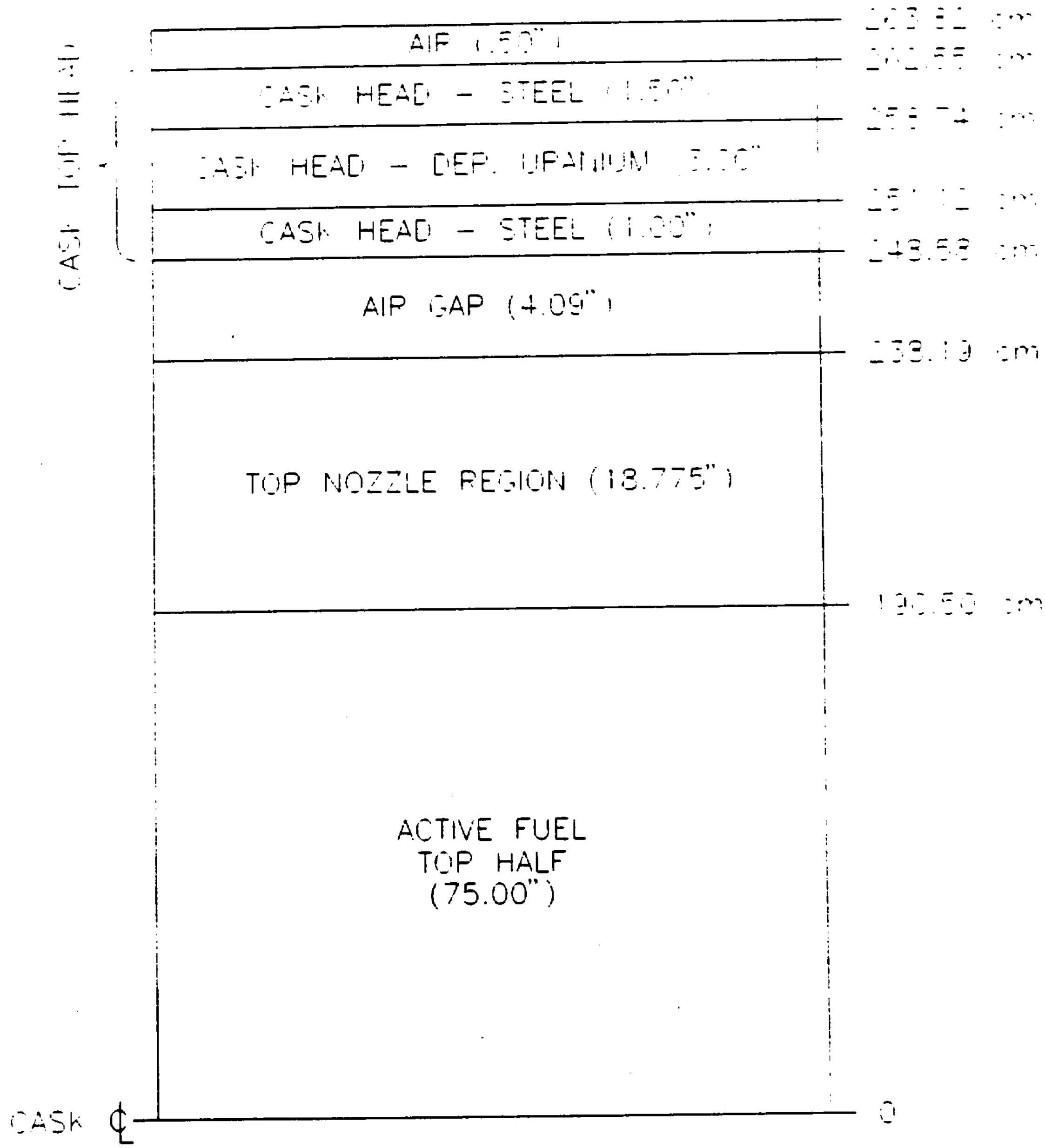


Figure A-5.4-3

ANISN Model for Cask Top Axial Dose Rates

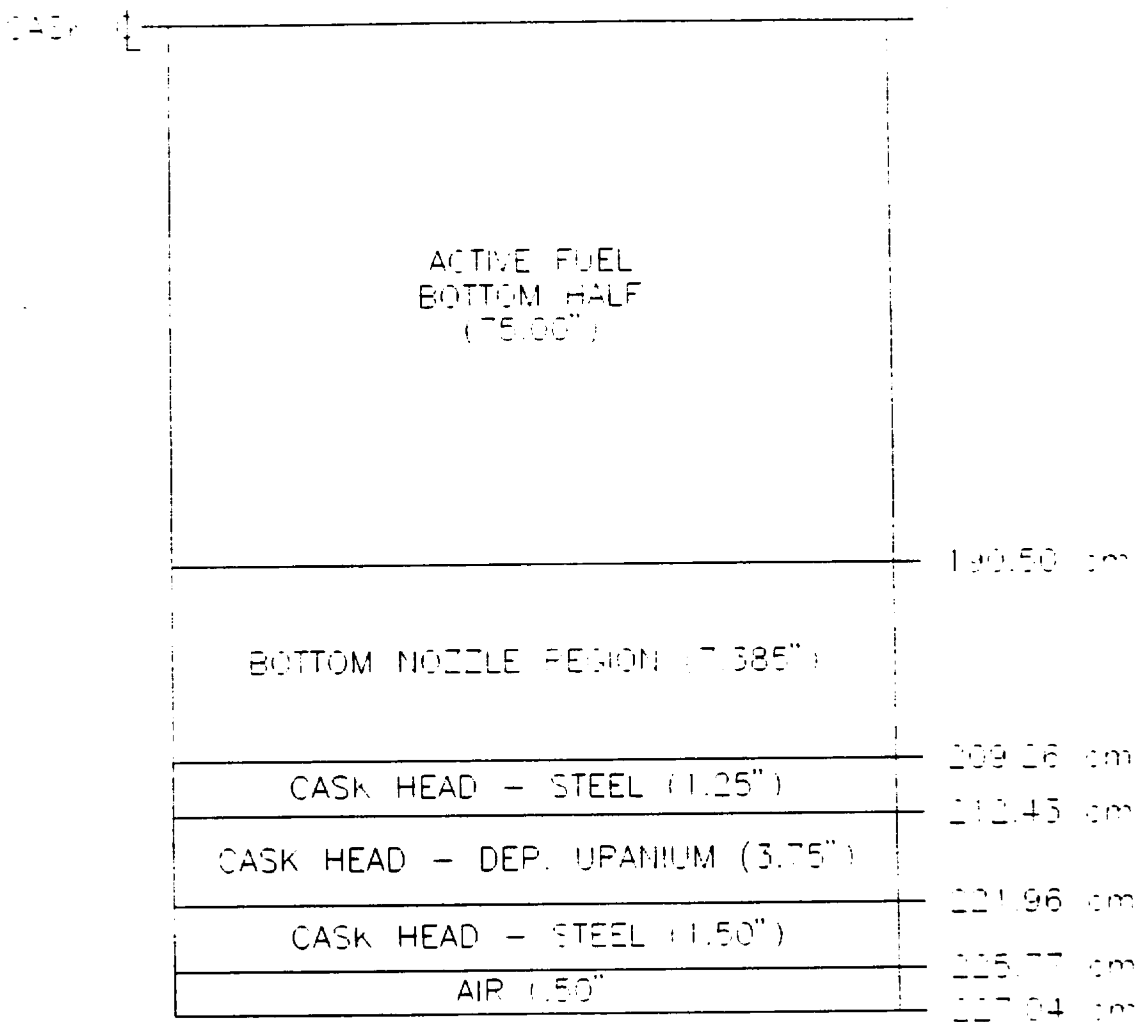


Figure A-5.4-4

ANISN Model for Cask Bottom Axial Dose Rates

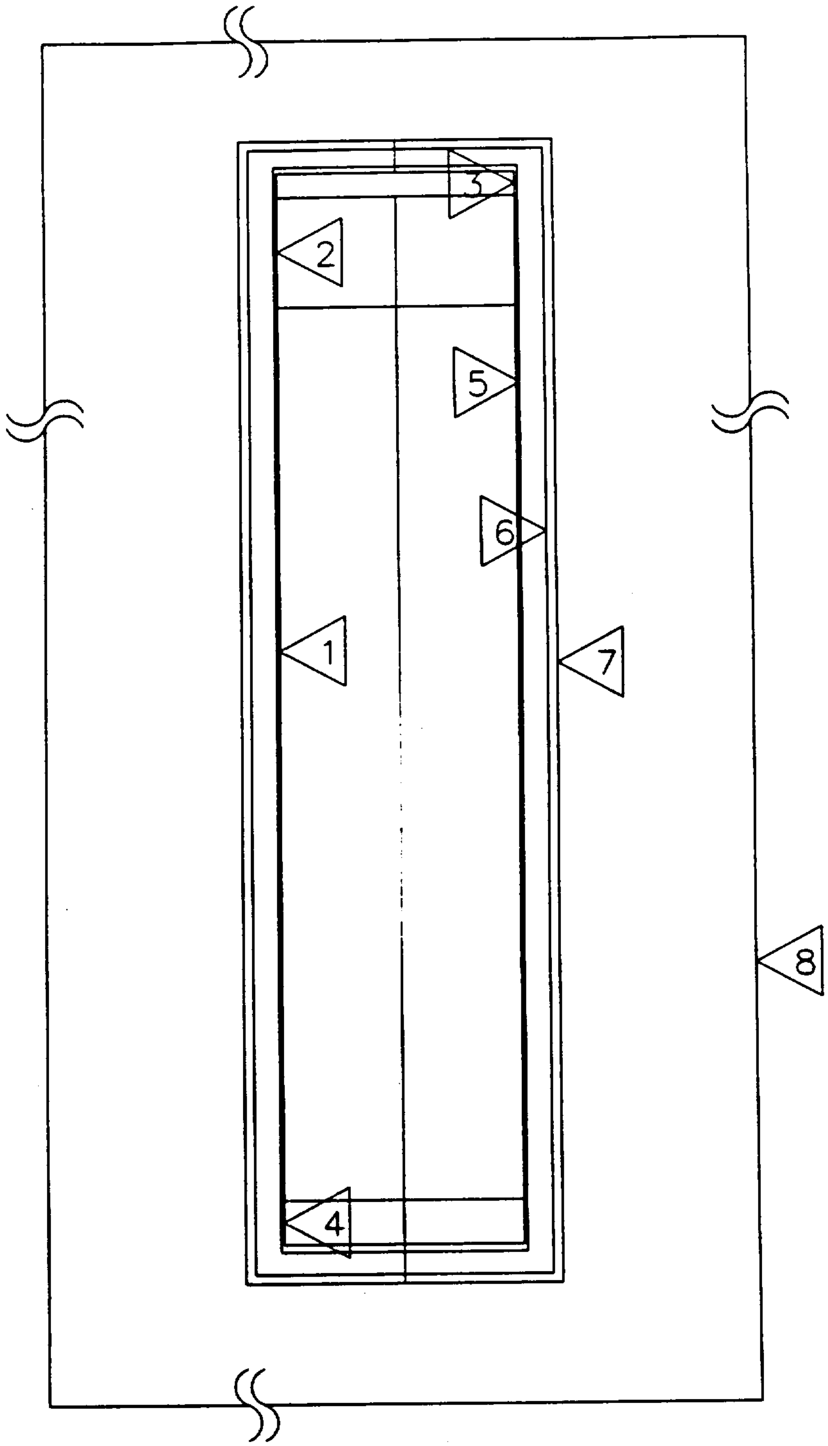


Figure A-5.4-5

IF-300 Channelled BWR Fuel Basket QAD-CGGP
Analytical Model Bodies

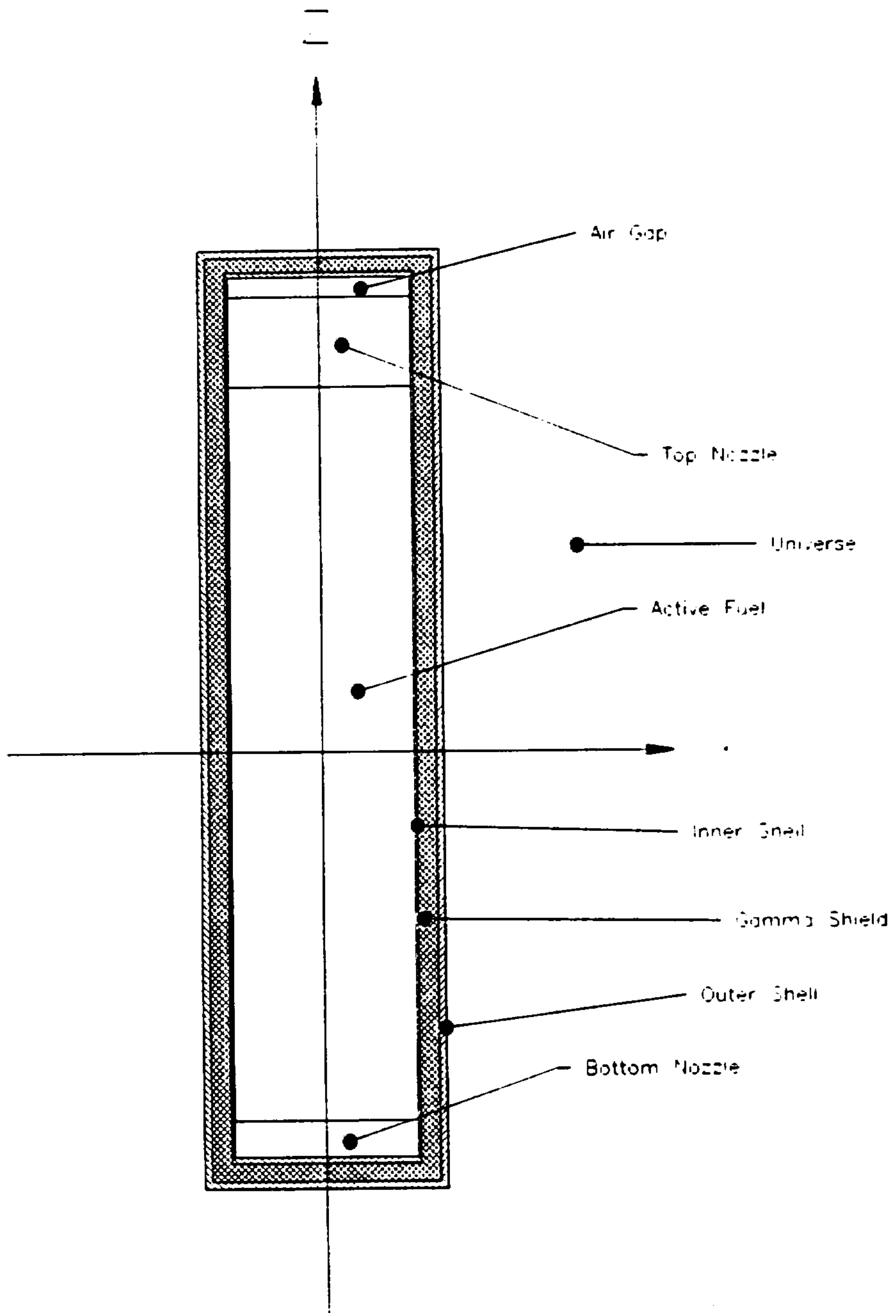


Figure A-5.4-6

IF-300 Channelled BWR Fuel Basket QAD-CGGP Zones

A-5.5 Appendix

A-5.5.1 References

[1] "Certificate of Compliance for Radioactive Materials Packages," Model No. IF-300, Certificate No. 9001, Revision 23, Package Identification No. USA/9001/B( )F, May 1990.

[2] "Packaging and Transportation of Radioactive Materials," Title 10, Code of Federal Regulations, Part 71 (10CFR71), USNRC, 5/31/88.

[3] Title 49 Code of Federal Regulations Part 173 (49CFR173) Section 441, USNRC.

[4] Consolidated Safety Analysis Report for IF-300 Shipping Cask, NEDO-10084-3, Volumes 1 and 2, General Electric Company, Docket No. 71-9001, May 1985.

[5] RSIC Computer Code Collection, ORIGEN2, Isotope Generation and Depletion Code - Matrix Exponential Method CCC-371, Oak Ridge National Laboratory - Updated January 1987, which contains ORNL/TM-7175 dated July 1980.

[6] "Physical Characteristics of G.E. BWR Fuel Assemblies," ORNL/TM-10902, Oak Ridge National Laboratory, June 1989.

[7] "Revised Uranium-Plutonium Cycle PWR and BWR Models for the ORIGEN Computer Code," ORNL/TM-6051, Oak Ridge National Laboratory, September 1978.

[8] U. S. Department of Energy, "Characteristics of Spent Fuel, High Level Waste, and Other Radioactive Wastes Which May Require Long Term Isolation," Office of Civilian Radioactive Waste Management, DOE/RW-0184, December 1987.

[9] Letter, R. K. Kunita (CP&L) to W. C. Wheadon (PNSI), dated January 4, 1990.

[10] "Spent Fuel Assembly Hardware: Characterization and 10CFR61 Classification for Waste Disposal," PNL-6906, Volume 1, Pacific Northwest Laboratory, June 1989.

[11] "RSIC Data Library Collection, Cask 81, 22 Neutron, 18 Gamma-Ray Group, P3, Cross Sections for Shipping Cask Analysis," Oak Ridge National Laboratory, Radiation Shielding Information Center, DLC-23, 1987.

[12] RSIC Computer Code Collection, "ANISN/PC," Oak Ridge National Laboratory - CCC-514 Micro, 1988.

[13] "QAD-CGGP: A Combinatorial Geometry Version of QAD-P5A, A Point Kernel Code System for Neutron and Gamma-Ray Shielding Calculations Using the GP Buildup Factor," Oak Ridge National Laboratory, RSIC Computer Code Collection, CCC-493, 1986.

[14] American National Standard Neutron and Gamma-Ray Flux-to-Dose Rate Factors, ANSI/ANS-6.1.1-1977, American Nuclear Society.

[15] Lamarsh, John R., "Introduction to Nuclear Engineering," Addison Wesley Publishing Co., 1977.

A-5.5.2 Reference Calculations

[A] IF-300 Shipping Cask BWR Basket Shielding Material Densities Calculation, PNFSI Calculation No. 420-11.0202, Revision 1.

[B] IF-300 Shipping Cask BWR Basket Axial Gamma Dose Calculation, PNFSI Calculation No. 420-11.0209, Revision 1.

[C] Neutron Dose in the Radial and Axial Directions and Gamma Dose in the Radial Direction of IF-300 Cask with BWR Fuel Basket, PNFSI Calculation No. 420-11.0210, Revision 1.

[D] IF-300 Shipping Cask Channelled BWR Fuel Basket, Dose Rate on the Cask Surface Near the Depleted Uranium Shield Blocks, PNFSI Calculation No. 420-11.0211, Revision 1.

A-5.5.3 Calculation of Attenuation Factors

1. Calculation of Attenuation Factors at 1 Meter, 6 Ft. From Cask Top Nozzle Region and 2 Meters From Transport Vehicle Surface

The gamma dose rate results from ANISN on the surface of the cask at the top nozzle region are used to calculate the dose rate at 6 ft. from the cask surface and 2 meters from the transport vehicle surface. To estimate these dose rates, the attenuation factors for gamma's are calculated in this section.

The method used here is based on treating the top nozzle portion of the cask as an equivalent disk source. It is assumed that the surface flux is semi-isotropic (100% outwardly directed) and no credit is taken for attenuation or buildup in air. The dose rates on the surface of the cask are calculated by multiplying the interval midpoint fluxes from the ANISN results with the flux-to-dose conversation factors. The interval midpoint fluxes

from ANISN used in calculating the dose rates are the same as the right boundary fluxes at the location of interval midpoints. The assumption of semi-isotropic surface flux forces all the particle to be emitted in the 0 to 2π steradians (i.e. 100% outwardly directed). This assumption is reasonable and conservative for the sources behind thick shield material layers. This assumption is reasonable and conservative for the sources behind thick shield material layers. Only spatial attenuation is considered.

The top nozzle source cylinder has the following dimensions as shown in the Figure below:

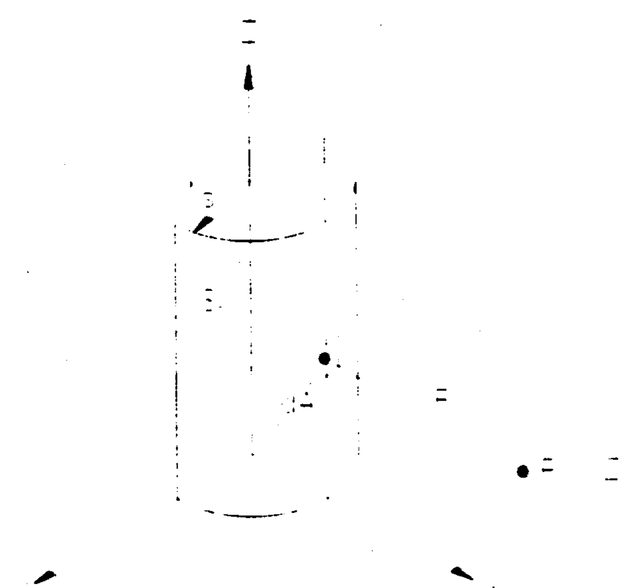
zmin:	= 0	Extent of Top Nozzle Region
zmax:	= 18.775"	
rs:	= 24.75"	Cask Outer Radius

Dose Point P Coordinates (x=0):

Distance from cylinder centerline to dose point P -

Py = rs + 108.49 Py = 133.24

Similarly, the values of Py for dose points at 1 meter and 6 ft from the cask surface are 64.12", and 99.25" respectively.



Use same origin as zmin, zmax above

$$Pz = \frac{zmax}{2} \qquad Pz = 9.387$$

Calculate Dose Attenuation Factor (DAF):

For Surface Source S and dose point P,

dDp/Davg = dA/(2πR^2)
= (rs*dΦ) (dz) / [(2π) (R^2)]

The term dDp is the dose rate at point P due to the surface source with area dA, and the term Davg is the average dose rate on the surface due to surface source S shown in the Figure above. Note that the average dose rate on the surface S is conservatively assumed to be the maximum dose rate calculated by the computer code ANISN as described in Section A-5.4.1.

R^2 = (rs cos Φs)^2 + (rs sinΦs - Py)^2 + (zs - Pz)^2

Integrate only over "visible" angle Φ.

$$\phi_{max} = \left[\frac{\pi}{2}\right] + \operatorname{acos}\left[\frac{rs}{Py}\right] = 2.955$$

$$\phi_{min} = \left[\frac{\pi}{2}\right] - \operatorname{acos}\left[\frac{rs}{Py}\right] = 0.187$$

$$DAF = \frac{1}{2\pi}\cdot\int_{zmin}^{zmax}\int_{\phi_{min}}^{\phi_{max}} \frac{rs}{(rs\cdot\cos(\phi))^2 + (rs\cdot\sin(\phi) - Py)^2 + (z - Pz)^2}\, d\phi\, dz$$

The values for DAF were calculated by substituting the above inputs into the equation for DAF, and then the integral for DAF was evaluated using numerical integration techniques.

$$DAF = 0.015 \qquad \text{and} \qquad \frac{1}{DAF} = 66.075$$

Using the same method as described above, the dose attenuation factors at 1 meter and 6 feet from the top nozzle surface for sources on the surface of cask top nozzle region are 0.09, and 0.03, respectively.

The neutrons and gammas on the top nozzle portion of the cask side surface (dose point R_0, in Figure A-5.3-1) also contribute to the dose at 1 meter (dose point R_1 in Figure A-5.3-1), and 6 feet from the cask centerline surface and 2 meters from the edge of the transport vehicle (dose point R_2 in Figure A-5.3-1). The dose attenuation factors for these dose points are 0.022, 0.015 and 0.01 respectively. These attenuation factors are calculated using the same methodology as described above except the input parameter P_z used in the equation for DAF is: -75".

The neutrons and gamma's on the active fuel portion of the cask side surface (dose point R_0 in Figure A-5.3-1) also contribute to the dose at 1 meter (dose point R_1' in Figure A-5.3-1), 6 feet from the top nozzle surface and 2 meters from the edge of transport vehicle (dose point R_2' in Figure A-5.3-1). The dose attenuation factors for these dose points are 0.246, 0.129 and 0.081, respectively. These attenuation factors are calculated using the same methodology as described above for the sources in the top nozzle portion of the cask. The following inputs are used in the equation for DAF to calculate these values:

Φ_{min} = 0.187 (same as top nozzle sources),

Φ_{max} = 2.955 (same as top nozzle sources),

Z_{min} = 0.0" (note the origin is now at the bottom ofactive fuel region),

Z_{max} = 150.0",

rs = 24.75",

P_z = 150.0 + 9.387 = 159.387",

P_y = 64.12", 99.25", and 133.24" for dose points at 1 meter, and 6 ft from the cask surfaces and 2 meter from the edge of transport vehicle respectively.

The values for DAF were again calculated by substituting the above inputs into the equation for DAF, and then the integral for DAF was evaluated using numerical integration techniques.

2. <u>Calculation of Attenuation Factors at 2 Meters From Transport Vehicle Surfaces in Axial Direction</u>

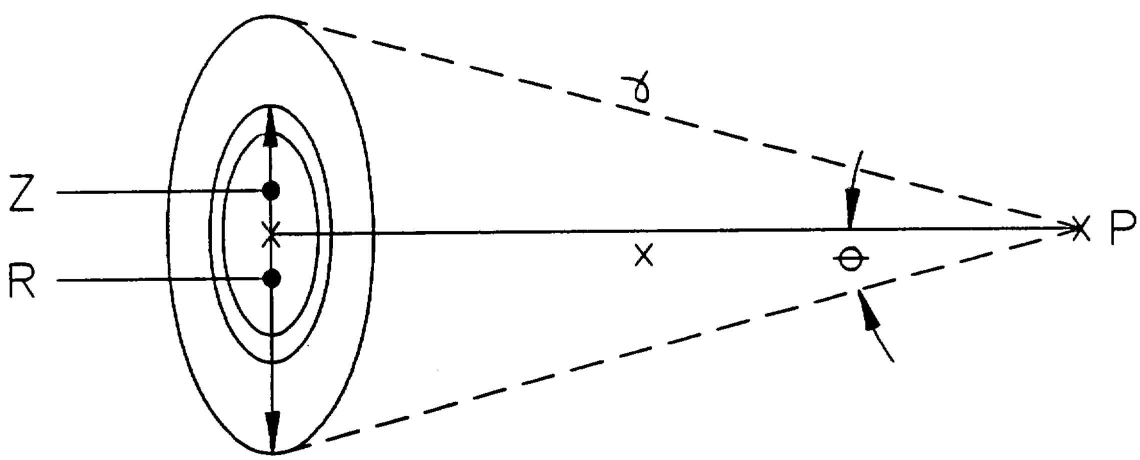
The attenuation factors for neutrons in the cask top and bottom axial directions at 2 meters from the edge of the transport vehicle are calculated for the IF-300 Cask on the transport vehicle. The 2 meter distance from the edge of the vehicle is conservatively assumed to be 9 ft. (274.3 cm) from the cask top or bottom axial surface [A-5.5.1-4]. The methodology is as follows:

A. Attenuation Factors Based on Analytical Method

The top of the bottom surface of the cask can be treated as a plate source with radius equal to the outside radius of the cask. Note that this assumption is conservative since the sources are only located in the cask inner cavity region which has a smaller radius than the cask (i.e., 78.83 cm vs. 47.625 cm).

Therefore the flux at a distance X cm from the center of a plate of radius R emitting S fission neutrons per cm^2/sec is given by:

$$\Phi(X) = 2\pi S \int_0^R G(\gamma)\ ZdZ \ . \ . \ .$$ (Eq. 10.63 of [A-5.5.1-15]



$X^2+Z^2 = \gamma^2$ and $ZdZ = \gamma d\gamma$ then

$$\Phi(X) = 2\pi S \int_X^{X\sec\theta} G(\gamma)\ \gamma\ d\gamma$$

where: $\Phi(X)$ = flux at distance X (neutrons/ cm^2-sec)

Neglecting any attenuation by air between the plate and the dose point P, and considering spatial attenuation, $G(\gamma)$ is given by the following:

$G(\gamma) = 1/2\pi\gamma^2$ (Eq. 10.64 [A-5.5.1-15] neglecting air attenuation and assuming semi-isotopic source)

$$\therefore \Phi(X) = S \int_{X}^{X\sec\theta} 1/\gamma \, d\gamma$$

$$\Phi(X) = S\,(\ln\,(x \sec\theta) - \ln X)$$

For this analysis, X = 274 cm (2 meters from edge of transport vehicle surface) and R = 78.83 cm. are used to calculate the axial dose attenuation.

$$\therefore \theta = \tan^{-1} \frac{78.83}{274} = 16.05° = 0.28 \text{ Radius}$$

$$\therefore \sec\theta = 1.041$$

$$\therefore \Phi(274 \text{ cm}) = S\,(\ln 274 \times 1.041 - \ln 274)$$

$$\Phi(274 \text{ cm}) = 0.040\ S$$

Since the dose rate is directly proportional to the flux, the dose rate at point P will also be reduced by 0.040.

B. Bounding Attenuation Factors

Based on the above results for calculating the attenuation of neutrons at 2 meters from the transport vehicle surface, the bounding attenuation factors are as follows:

1. For the cask top axial direction, the attenuation factor is 0.04 at 2 meters from the edge of the transport vehicle.

2. For the cask bottom axial direction the bounding attenuation factor is 0.04 at 2 meters from the edge of transport vehicle.

3. Calculation of Attenuation Factors at the Cask Enclosure

From Figure A-5.3-2 the distance between the outermost fins of the cask to the aluminum enclosure is 16.125", and the distance between the aluminum enclosure and the conveyance bed edge is 15". The distance between the cask top head region and the surface of the aluminum enclosure in the cask radial direction is 22.41". In calculating attenuation factors, distances of 15.75", 14" and 22.033", instead of 16.125", 15", and 22.41", respectively, are conservatively used. The attenuation factors for the dose point on the surface of the aluminum enclosure due to sources in the top nozzle and active fuel region of the fuel assembly are calculated using the same method as that of Section A-5.5.3.1.

The following input parameters are used to evaluate the integral for the dose attenuation factor (DAF).

For sources in the top nozzle region:

Φ_{min} = 0.187 (same as Section A-5.5.3.1),

Φ_{max} = 2.955 (same as Section A-5.5.3.1),

Z_{min} = 0.0 (same as Section A-5.5.3.1),

Z_{max} = 18.775" (same as Section A-5.5.3.1),

rs = 24.75" (same as Section A-5.5.3.1),

P_z = 9.387" (same as Section A-5.5.3.1),

P_y = 22.033 + 24.75 = 46.78" for dose points on the surface of the aluminum enclosure

The value for DAF was calculated by substituting the above inputs into the equation for DAF and then the integral for DAF was evaluated using numerical integration techniques. The results show that the value of DAF for sources in the top nozzle region is 0.219.

Similarly for sources in the active fuel region:

Φ_{min} = 0.187 (same as top nozzle sources),

Φ_{max} = 2.955 (same as top nozzle sources),

Z_{min} = 0.0" (note the origin is now at the bottom of active fuel region),

Z_{max} = 150.0",

rs = 24.75",

P_z = 150.0 + 9.387 = 159.387",

P_y = 15.75 + 24.75 = 40.50" for dose points on the surface of the aluminum enclosure

Solving as discussed above, the value of DAF for sources in the active fuel region is 0.451.

These attenuation factors are used to calculate the dose on the surface of aluminum enclosure due to sources in the active fuel and the top nozzle regions of the fuel assemblies.

A-5.5.4 Input/Output Listings

1. ORIGEN2 Input and Partial Output Listings

```
-1
-1
-1
RDA  ########################################################
RDA  ##                                                    ##
RDA  ##   IF-300 REDESIGNED BWR BASKET 17 FUEL ASSEM       ##
RDA  ##   PNFS Project 420-0400                            ##
RDA  ##   Input Filename:          B35-265.U5              ##
RDA  ##   Creation Date:           3/21/90                 ##
RDA  ##   Fuel Type:               2.65% OCRWM DATABASE    ##
RDA  ##   Burnup:                  35000 MWd/MTIHM         ##
RDA  ##   FOR N,G SOURCE TERMS WITH LOWER ENRICHMENT       ##
RDA  ########################################################
RDA
LIP  0  0  0
LIB  -1 1 2 3      251      252      253    9   3   0   1   4
PHO  101  102   103   10
RDA  READ UNIT AMOUNTS OF FUEL AND FUEL ASSEM MAT WITH CHANNELS
INP        -1  1  -1  -1  1  1  ONE MTIHM UO2
INP        -2  1  -1  -1  1  1  ONE KG ZIRCALOY-4
INP        -3  1  -1  -1  1  1  ONE KG ZIRCALOY-2
INP        -4  1  -1  -1  1  1  ONE KG INCONEL-X750
INP        -5  1  -1  -1  1  1  ONE KG SS 302
INP        -6  1  -1  -1  1  1  ONE KG SS 304
RDA  MIX TOP, PLENUM, IN-CORE, AND BOTTOM MIXTURES
RDA  MIX TOP ZONE
MOV        -2         -7        0     0.000 ZIRCALOY-4
ADD        -3         -7        0     0.000 ZIRCALOY-2
ADD        -4         -7        0     0.000 INCONEL-X750
ADD        -5         -7        0     0.000 SS302
ADD        -6         -7        0     3.206 SS304
RDA  MIX PLENUM ZONE
MOV        -2         -8        0     3.800 ZIRCALOY-4
ADD        -3         -8        0     4.700 ZIRCALOY-2
ADD        -4         -8        0     0.000 INCONEL-X750
ADD        -5         -8        0     1.100 SS302
ADD        -6         -8        0     0.000 SS304
RDA  MIX IN-CORE ZONE - SANS UO2
MOV        -2         -9        0    43.660 ZIRCALOY-4
ADD        -3         -9        0    51.200 ZIRCALOY-2
ADD        -4         -9        0     0.360 INCONEL-X750
ADD        -5         -9        0     0.000 SS302
ADD        -6         -9        0     0.000 SS304
RDA  MIX BOTTOM ZONE
MOV        -2        -10        0     0.000 ZIRCALOY-4
ADD        -3        -10        0     0.000 ZIRCALOY-2
ADD        -4        -10        0     0.400 INCONEL-X750
ADD        -5        -10        0     0.000 SS302
ADD        -6        -10        0     6.006 SS304
RDA  IRRADIATE ONE MTIHM OF UO2 AT 100% POWER
BUP
IRP     112.61      25.9        -1        1   4   2  BURNUP = 2917 MWD/MTIHM
IRP     225.22      25.9         1        1   4   0  BURNUP = 5833 MWD/MTIHM
IRP     337.83      25.9         1        1   4   0  BURNUP = 8750 MWD/MTIHM
DEC     443.83                   1        1   4   0  106 DAY OUTAGE
```

IRP	556.44	25.9	1	1	4	0	BURNUP = 11666 MWD/MTIHM
IRP	669.05	25.9	1	1	4	0	BURNUP = 14583 MWD/MTIHM
IRP	781.66	25.9	1	1	4	0	BURNUP = 17500 MWD/MTIHM
DEC	887.66		1	1	4	0	106 DAY OUTAGE
IRP	1000.27	25.9	1	1	4	0	BURNUP = 20416 MWD/MTIHM
IRP	1112.88	25.9	1	1	4	0	BURNUP = 23333 MWD/MTIHM
IRP	1225.49	25.9	1	1	4	0	BURNUP = 26250 MWD/MTIHM
DEC	1331.49		1	1	4	0	106 DAY OUTAGE
IRP	1444.10	25.9	1	1	4	0	BURNUP = 29166 MWD/MTIHM
IRP	1556.71	25.9	1	1	4	0	BURNUP = 32083 MWD/MTIHM
IRP	1669.34	25.9	1	1	4	0	BURNUP = 35000 MWD/MTIHM
BUP							
RDA							
RDA	IRRADIATE TOP ZONE MATERIAL AT 10% FLUX						
IRF	112.61	-0.1	-7	7	4	2	
IRF	225.22	-0.1	7	7	4	0	
IRF	337.83	-0.1	7	7	4	0	
DEC	443.83		7	7	4	0	
IRF	556.44	-0.1	7	7	4	0	
IRF	669.05	-0.1	7	7	4	0	
IRF	781.66	-0.1	7	7	4	0	
DEC	887.66		7	7	4	0	
IRF	1000.27	-0.1	7	7	4	0	
IRF	1112.88	-0.1	7	7	4	0	
IRF	1225.49	-0.1	7	7	4	0	
DEC	1331.49		7	7	4	0	
IRF	1444.10	-0.1	7	7	4	0	
IRF	1556.71	-0.1	7	7	4	0	
IRF	1669.34	-0.1	7	7	4	0	
RDA							
RDA	IRRADIATE PLENUM ZONE MATERIAL AT 20% FLUX						
IRF	112.61	-0.2	-8	8	4	2	
IRF	225.22	-0.2	8	8	4	0	
IRF	337.83	-0.2	8	8	4	0	
DEC	443.83		8	8	4	0	
IRF	556.44	-0.2	8	8	4	0	
IRF	669.05	-0.2	8	8	4	0	
IRF	781.66	-0.2	8	8	4	0	
DEC	887.66		8	8	4	0	
IRF	1000.27	-0.2	8	8	4	0	
IRF	1112.88	-0.2	8	8	4	0	
IRF	1225.49	-0.2	8	8	4	0	
DEC	1331.49		8	8	4	0	
IRF	1444.10	-0.2	8	8	4	0	
IRF	1556.71	-0.2	8	8	4	0	
IRF	1669.34	-0.2	8	8	4	0	
RDA							
RDA	IRRADIATE CORE ZONE (SANS UO2) AT 100% FLUX						
IRF	112.61	-1.0	-9	9	4	2	
IRF	225.22	-1.0	9	9	4	0	
IRF	337.83	-1.0	9	9	4	0	
DEC	443.83		9	9	4	0	
IRF	556.44	-1.0	9	9	4	0	
IRF	669.05	-1.0	9	9	4	0	
IRF	781.66	-1.0	9	9	4	0	

```
DEC      887.66              9        9        4        0
IRF     1000.27    -1.0      9        9        4        0
IRF     1112.88    -1.0      9        9        4        0
IRF     1225.49    -1.0      9        9        4        0
DEC     1331.49              9        9        4        0
IRF     1444.10    -1.0      9        9        4        0
IRF     1556.71    -1.0      9        9        4        0
IRF     1669.34    -1.0      9        9        4        0
RDA
RDA     IRRADIATE BOTTOM ZONE MATERIAL AT 15% FLUX
IRF      112.61    -0.15   -10       10        4        2
IRF      225.22    -0.15    10       10        4        0
IRF      337.83    -0.15    10       10        4        0
DEC      443.83             10       10        4        0
IRF      556.44    -0.15    10       10        4        0
IRF      669.05    -0.15    10       10        4        0
IRF      781.66    -0.15    10       10        4        0
DEC      887.66             10       10        4        0
IRF     1000.27    -0.15    10       10        4        0
IRF     1112.88    -0.15    10       10        4        0
IRF     1225.49    -0.15    10       10        4        0
DEC     1331.49             10       10        4        0
IRF     1444.10    -0.15    10       10        4        0
IRF     1556.71    -0.15    10       10        4        0
IRF     1669.34    -0.15    10       10        4        0
RDA
RDA     MIX A COMBINED IN-CORE ZONE
MOV           9      11      0      1.0
ADD           1      11      0    0.198
RDA     MIX A WHOLE ASSEMBLY OUT OF THE PARTS
MOV           7      12      0      1.0 TOP ZONE
ADD           8      12      0      1.0 PLENUM ZONE
ADD          10      12      0      1.0 BOTTOM ZONE
ADD          11      12      0      1.0 (COMBINED) IN-CORE ZONE
RDA     MOVE ASSEMBLY PARTS TO SCRATCH VECTORS
MOV           7      -1      0      1.0 TOP ZONE
MOV           8      -2      0      1.0 PLENUM ZONE
MOV          11      -3      0      1.0 (COMBINED) IN-CORE ZONE
MOV          10      -4      0      1.0 BOTTOM ZONE
MOV          12      -5      0      1.0 WHOLE ASSEMBLY
TIT     SOURCE CHARACTERISTICS OF 2.65%,35.0 GWD/MTIHM FUEL AT DISCHARGE
BAS     ONE GE8X8 FUEL ASSEMBLY
OPTL    8 8 8 8 8   8 8 8 7 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
OPTA    8 8 8 8 8   8 8 8 7 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
OPTF    8 8 8 8 8   8 8 8 7 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
CUT     9 .01  25 .01  26 .01  27 .01    -1
RDA     MOVE VECTORS -1 THRU -5 TO POSITIVE VECTORS FOR OUTPUT
MOV          -1       1      0      1.0
MOV          -2       2      0      1.0
MOV          -3       3      0      1.0
MOV          -4       4      0      1.0
MOV          -5       5      0      1.0
HED           1 TOP
HED           2 PLENUM
HED           3 IN-CORE
```

```
HED          4 BOTTOM
HED          5 WHOLE
OUT     -5   1    -1   0
TIT     SOURCE CHARACTERISTICS OF 2.65%.35.0 GWD/MTIHM FUEL AFTER 2 YRS
DEC          2        -1        1        5        4
DEC          2        -2        2        5        4
DEC          2        -3        3        5        4
DEC          2        -4        4        5        4
DEC          2        -5        5        5        4
HED          1 TOP
HED          2 PLENUM
HED          3 IN-CORE
HED          4 BOTTOM
HED          5 WHOLE
OUT     -5   1    -1   0
TIT     SOURCE CHARACTERISTICS OF 2.65%.35.0 GWD/MTIHM FUEL AFTER 3 YRS
DEC          3        -1        1        5        4
DEC          3        -2        2        5        4
DEC          3        -3        3        5        4
DEC          3        -4        4        5        4
DEC          3        -5        5        5        4
HED          1 TOP
HED          2 PLENUM
HED          3 IN-CORE
HED          4 BOTTOM
HED          5 WHOLE
OUT     -5   1    -1   0
TIT     SOURCE CHARACTERISTICS OF 2.65%.35.0 GWD/MTIHM FUEL AFTER 4 YRS
DEC          4        -1        1        5        4
DEC          4        -2        2        5        4
DEC          4        -3        3        5        4
DEC          4        -4        4        5        4
DEC          4        -5        5        5        4
HED          1 TOP
HED          2 PLENUM
HED          3 IN-CORE
HED          4 BOTTOM
HED          5 WHOLE
OUT     -5   1    -1   0
TIT     SOURCE CHARACTERISTICS OF 2.65%.35.0 GWD/MTIHM FUEL AFTER 5 YRS
DEC          5        -1        1        5        4
DEC          5        -2        2        5        4
DEC          5        -3        3        5        4
DEC          5        -4        4        5        4
DEC          5        -5        5        5        4
HED          1 TOP
HED          2 PLENUM
HED          3 IN-CORE
HED          4 BOTTOM
HED          5 WHOLE
OUT     -5   1    -1   0
END
    2    922340    53.12    922350  26500.0    922380 973446.9          0 0.00E+00     1 MTIHM FUEL ACTINIDES
    4     30000 1.00E+00     50000 1.00E+00     60000 8.94E+01      80000 1.19E+05     1 MTIHM FUEL IMPUR
    4     90000 1.07E+01    110000 1.50E+01    130000 1.67E+01     140000 1.21E+01     1 MTIHM FUEL IMPUR
```

4	150000	3.50E+01	200000	2.00E+00	220000	1.00E+00	240000	3.00E+00	1 MTIHM FUEL IMPUR
4	250000	1.70E+00	260000	1.80E+01	270000	1.00E+00	290000	1.00E+00	1 MTIHM FUEL IMPUR
4	300000	4.03E+01	420000	1.00E+01	480000	2.50E+01	490000	2.00E+00	1 MTIHM FUEL IMPUR
4	500000	4.00E+00	740000	2.00E+00	820000	1.00E+00	830000	4.00E-01	1 MTIHM FUEL IMPUR
0									
4	10000	1.30E-02	50000	3.30E-04	60000	1.20E-01	70000	8.00E-02	1 KG ZIRC-4
4	80000	9.50E-01	130000	2.40E-02	160000	3.50E-02	220000	2.00E-02	1 KG ZIRC-4
4	230000	2.00E-02	240000	1.25E+00	250000	2.00E-02	260000	2.25E+00	1 KG ZIRC-4
4	270000	1.00E-02	280000	2.00E-02	290000	2.00E-02	400000	9.80E+02	1 KG ZIRC-4
4	410000	1.20E-01	480000	2.50E-04	500000	1.60E+01	720000	7.80E-02	1 KG ZIRC-4
4	740000	2.00E-02	922340	2.00E-04	0	0.00E+00	0	0.00E+00	1 KG ZIRC-4
0									
4	10000	1.30E-02	50000	3.30E-04	60000	1.20E-01	70000	8.00E-02	1 KG ZIRC-2
4	80000	9.50E-01	130000	2.40E-02	160000	3.50E-02	220000	2.00E-02	1 KG ZIRC-2
4	230000	2.00E-02	240000	1.00E+00	250000	2.00E-02	260000	1.50E+00	1 KG ZIRC-2
4	270000	1.00E-02	280000	5.00E-01	290000	2.00E-02	400000	9.80E+02	1 KG ZIRC-2
4	410000	1.20E-01	480000	2.50E-04	500000	1.60E+01	720000	7.80E-02	1 KG ZIRC-2
4	740000	2.00E-02	0	0.00E+00	0	0.00E+00	0	0.00E+00	1 KG ZIRC-2
0									
4	60000	4.00E-01	70000	1.30E+00	130000	8.00E+00	140000	3.00E+00	1 KG INC-X750
4	160000	7.00E-02	220000	2.49E+01	240000	1.50E+02	250000	7.00E+01	1 KG INC-X750
4	260000	6.78E+01	270000	6.49E+00	280000	7.22E+02	290000	5.00E-01	1 KG INC-X750
4	410000	9.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	1 KG INC-X750
0									
4	60000	1.50E+00	70000	1.30E+00	140000	1.00E+01	150000	4.50E-01	1 KG SS-302
4	160000	3.00E-01	240000	1.80E+02	250000	2.00E+01	260000	6.98E+02	1 KG SS-302
4	270000	8.00E-01	280000	8.92E+01	410000	1.00E-01	0	0.00E+00	1 KG SS-302
0									
4	60000	8.00E-01	70000	1.30E+00	140000	1.00E+01	150000	4.50E-01	1 KG SS-304
4	160000	3.00E-01	240000	1.90E+02	250000	2.00E+01	260000	6.88E+02	1 KG SS-304
4	270000	8.00E-01	280000	8.92E+01	410000	1.00E-01	0	0.00E+00	1 KG SS-304
0									

* SOURCE CHARACTERISTICS OF 2.65%,35.0 GWD/MTIHM FUEL AFTER 3 YRS
POWER= 1.00000E+00 MW, BURNUP= 1.00000E+00 MWD, FLUX= 1.00E+00 N/CM**2-SEC

0 REACTIVITY AND BURNUP DATA

BASIS= ONE GE8X8 FUEL ASSEMBLY

	TOP	PLENUM	IN-CORE	BOTTOM	WHOLE
TIME, SEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.47E+07
NEUT. FLUX	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SP POW,MW	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BURNUP,MWD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K INFINITY	.00000	.00000	.00000	.00000	.80786
NEUT PRODN	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.43E+03
NEUT DESTN	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.77E+03
TOT BURNUP	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AVG N FLUX	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AVG SP POW	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

SIZE OF MMAX(I): MMAX= 1 #= 876 MMAX= 2 #= 432 MMAX= 3 #= 142 MMAX= 4 #= 50 MMAX= 5 #= 85 MMAX= 6 #= 58
MMAX= 7 #= 46 MMAX= 8 #= 0 MMAX= 9 #= 0 MMAX=10 #= 0 MMAX=11 #= 0 MMAX=12 #= 0

THE NUMBER OF NON-ZERO TERMS IN A=6466
THE NUMBER OF NON-ZERO FISSION PRODUCT YIELDS=3242
ILITE= 688 IACT= 129 IFP= 879 ITOT=1696
THE NUMBER OF NON-ZERO NATURAL ABUNDANCES= 437
THE NUMBER OF NON-ZERO PHOTON YIELDS= 7903
THE MAXIMUM NUMBER OF TERMS IN AP= 308

SOURCE CHARACTERISTICS OF 2.65%,35.0 GWD/MTIHM FUEL AFTER 3 YRS
(ALPHA,N) NEUTRON SOURCE, NEUTRONS/SEC
BASIS= ONE GE8X8 FUEL ASSEMBLY

	TOP	PLENUM	IN-CORE	BOTTOM	WHOLE
PU238	0.000E+00	0.000E+00	6.391E+05	0.000E+00	6.391E+05
PU239	0.000E+00	0.000E+00	4.446E+04	0.000E+00	4.446E+04
PU240	0.000E+00	0.000E+00	8.457E+04	0.000E+00	8.457E+04
AM241	0.000E+00	0.000E+00	1.578E+05	0.000E+00	1.578E+05
CM242	0.000E+00	0.000E+00	1.866E+05	0.000E+00	1.866E+05
CM244	0.000E+00	0.000E+00	8.767E+05	0.000E+00	8.767E+05
TOTALS					
TABLE	0.000E+00	0.000E+00	2.004E+06	0.000E+00	2.004E+06
ACTUAL	0.000E+00	0.000E+00	2.004E+06	0.000E+00	2.004E+06

1 OUTPUT UNIT = 11 PAGE 65

SOURCE CHARACTERISTICS OF 2.65%,35.0 GWD/MTIHM FUEL AFTER 3 YRS
SPONTANEOUS FISSION NEUTRON SOURCE, NEUTRONS/SEC
BASIS= ONE GE8X8 FUEL ASSEMBLY

	TOP	PLENUM	IN-CORE	BOTTOM	WHOLE
CM244	0.000E+00	0.000E+00	1.056E+08	0.000E+00	1.056E+08
TOTALS					
TABLE	0.000E+00	0.000E+00	1.079E+08	0.000E+00	1.079E+08
ACTUAL	0.000E+00	0.000E+00	1.079E+08	0.000E+00	1.079E+08

OVERALL TOTALS					
TABLE	0.000E+00	0.000E+00	1.099E+08	0.000E+00	1.099E+08
ACTUAL	0.000E+00	0.000E+00	1.099E+08	0.000E+00	1.099E+08

1 OUTPUT UNIT = 11 PAGE 66

PHOTON SPECTRUM FOR ACTIVATION PRODUCTS

0 SOURCE CHARACTERISTICS OF 2.65%.35.0 GWD/MTIHM FUEL AFTER 3 YRS

POWER= 1.00 MW, BURNUP= 1. MWD, FLUX= 1.00E+00 N/CM**2-SEC

0 18 GROUP PHOTON RELEASE RATES, PHOTONS/SECOND

BASIS= ONE GE8X8 FUEL ASSEMBLY

EMEAN	TOP	PLENUM	IN-CORE	BOTTOM	WHOLE
1.000E-02	4.988E+10	5.701E+10	1.677E+12	2.063E+11	1.991E+12
2.500E-02	7.551E+09	1.793E+11	9.684E+12	3.255E+10	9.904E+12
3.750E-02	4.299E+09	4.077E+10	2.124E+12	1.853E+10	2.188E+12
5.750E-02	4.843E+09	4.893E+09	1.321E+11	2.088E+10	1.627E+11
8.500E-02	1.904E+09	1.973E+09	5.462E+10	8.208E+09	6.671E+10
1.250E-01	7.313E+08	1.626E+09	6.883E+10	3.152E+09	7.434E+10
2.250E-01	2.406E+08	1.329E+10	7.257E+11	1.037E+09	7.403E+11
3.750E-01	6.750E+07	7.782E+10	4.286E+12	2.909E+08	4.364E+12
5.750E-01	9.088E+06	9.997E+10	5.509E+12	3.845E+07	5.609E+12
8.500E-01	4.170E+10	2.984E+10	5.325E+10	1.181E+11	2.429E+11
1.250E+00	1.641E+12	1.225E+12	2.076E+13	7.075E+12	3.071E+13
1.750E+00	9.667E+04	6.531E+04	2.270E+06	4.032E+05	2.835E+06
2.250E+00	8.699E+06	6.494E+06	1.100E+08	3.750E+07	1.627E+08
2.750E+00	2.692E+04	2.009E+04	3.403E+05	1.160E+05	5.033E+05
3.500E+00	1.109E-22	3.264E-15	1.940E-04	1.077E-13	1.940E-04
5.000E+00	0.000E+00	0.000E+00	5.775E-05	0.000E+00	5.775E-05
7.000E+00	0.000E+00	0.000E+00	3.747E-06	0.000E+00	3.747E-06
9.500E+00	0.000E+00	0.000E+00	2.370E-07	0.000E+00	2.370E-07
0 TOTAL	1.753E+12	1.732E+12	4.508E+13	7.484E+12	5.605E+13
0MEV/SEC	2.089E+12	1.654E+12	3.130E+13	8.950E+12	4.399E+13

PHOTON SPECTRUM FOR ACTINIDES + DAUGHTERS

0 SOURCE CHARACTERISTICS OF 2.65%.35.0 GWD/MTIHM FUEL AFTER 3 YRS

POWER= 1.00 MW, BURNUP= 1. MWD, FLUX= 1.00E+00 N/CM**2-SEC

0 18 GROUP PHOTON RELEASE RATES, PHOTONS/SECOND

BASIS= ONE GE8X8 FUEL ASSEMBLY

EMEAN	TOP	PLENUM	IN-CORE	BOTTOM	WHOLE
1.000E-02	0.000E+00	0.000E+00	1.205E+13	0.000E+00	1.205E+13
2.500E-02	0.000E+00	0.000E+00	1.592E+11	0.000E+00	1.592E+11
3.750E-02	0.000E+00	0.000E+00	5.224E+10	0.000E+00	5.224E+10
5.750E-02	0.000E+00	0.000E+00	2.282E+12	0.000E+00	2.282E+12
8.500E-02	0.000E+00	0.000E+00	2.246E+11	0.000E+00	2.246E+11
1.250E-01	0.000E+00	0.000E+00	2.010E+11	0.000E+00	2.010E+11
2.250E-01	0.000E+00	0.000E+00	1.634E+11	0.000E+00	1.634E+11
3.750E-01	0.000E+00	0.000E+00	8.858E+09	0.000E+00	8.858E+09
5.750E-01	0.000E+00	0.000E+00	1.599E+08	0.000E+00	1.599E+08
8.500E-01	0.000E+00	0.000E+00	3.645E+08	0.000E+00	3.645E+08
1.250E+00	0.000E+00	0.000E+00	1.806E+08	0.000E+00	1.806E+08
1.750E+00	0.000E+00	0.000E+00	4.156E+07	0.000E+00	4.156E+07
2.250E+00	0.000E+00	0.000E+00	2.126E+07	0.000E+00	2.126E+07
2.750E+00	0.000E+00	0.000E+00	3.842E+07	0.000E+00	3.842E+07
3.500E+00	0.000E+00	0.000E+00	1.109E+07	0.000E+00	1.109E+07
5.000E+00	0.000E+00	0.000E+00	4.745E+06	0.000E+00	4.745E+06

7.000E+00	0.000E+00	0.000E+00	5.471E+05	0.000E+00	5.471E+05
9.500E+00	0.000E+00	0.000E+00	6.286E+04	0.000E+00	6.286E+04
0 TOTAL	0.000E+00	0.000E+00	1.514E+13	0.000E+00	1.514E+13
0MEV/SEC	0.000E+00	0.000E+00	3.429E+11	0.000E+00	3.429E+11

PHOTON SPECTRUM FOR FISSION PRODUCTS

0 SOURCE CHARACTERISTICS OF 2.65%,35.0 GWD/MTIHM FUEL AFTER 3 YRS

POWER= 1.00 MW, BURNUP= 1. MWD, FLUX= 1.00E+00 N/CM**2-SEC

0 18 GROUP PHOTON RELEASE RATES, PHOTONS/SECOND

BASIS= ONE GE8X8 FUEL ASSEMBLY

EMEAN	TOP	PLENUM	IN-CORE	BOTTOM	WHOLE
1.000E-02	0.000E+00	0.000E+00	1.179E+15	0.000E+00	1.179E+15
2.500E-02	0.000E+00	0.000E+00	2.772E+14	0.000E+00	2.772E+14
3.750E-02	0.000E+00	0.000E+00	2.854E+14	0.000E+00	2.854E+14
5.750E-02	0.000E+00	0.000E+00	2.416E+14	0.000E+00	2.416E+14
8.500E-02	0.000E+00	0.000E+00	1.660E+14	0.000E+00	1.660E+14
1.250E-01	0.000E+00	0.000E+00	1.782E+14	0.000E+00	1.782E+14
2.250E-01	0.000E+00	0.000E+00	1.438E+14	0.000E+00	1.438E+14
3.750E-01	0.000E+00	0.000E+00	8.310E+13	0.000E+00	8.310E+13
5.750E-01	0.000E+00	0.000E+00	1.491E+15	0.000E+00	1.491E+15
8.500E-01	0.000E+00	0.000E+00	4.394E+14	0.000E+00	4.394E+14
1.250E+00	0.000E+00	0.000E+00	8.138E+13	0.000E+00	8.138E+13
1.750E+00	0.000E+00	0.000E+00	4.108E+12	0.000E+00	4.108E+12
2.250E+00	0.000E+00	0.000E+00	3.691E+12	0.000E+00	3.691E+12
2.750E+00	0.000E+00	0.000E+00	1.050E+11	0.000E+00	1.050E+11
3.500E+00	0.000E+00	0.000E+00	1.337E+10	0.000E+00	1.337E+10
5.000E+00	0.000E+00	0.000E+00	1.208E-05	0.000E+00	1.208E-05
7.000E+00	0.000E+00	0.000E+00	7.837E-07	0.000E+00	7.837E-07
9.500E+00	0.000E+00	0.000E+00	4.956E-08	0.000E+00	4.956E-08
0 TOTAL	0.000E+00	0.000E+00	4.574E+15	0.000E+00	4.574E+15
0MEV/SEC	0.000E+00	0.000E+00	1.492E+15	0.000E+00	1.492E+15

5.5.4.2 ANISN Radial Input and Dose Rate Output

```
[IFRAD2]IF3.17 BWR ASSEM.35K BUP.2.65W% ENRICH.3YR DECAY.CASK RADIAL
15$$    1     0     3     8     2          1     0     7    80     0
       40     3     4    43    52         36     0    56     0     0
        1     0     0    20     0          0     0     0     5     0
        0     0     0     1     1          0
16**    2R0.0     0.0001    1.420892 381.00
        4R0.0     0.5000    0.0002   F0.0
        T
14*
 0 +30165- 9 0 +     0+ 0 0 +73389- 5 0 +51569- 639R+     0+ 0 0 +31936- 9
                ********* cross sections suppressed *********
 0 -41762- 4 0 -80478- 537R+     0+ 0 0 +53965- 4 0 -27670- 441R+     0+ 0
 0 +18099- 4 0 -15392- 438R+     0+ 0
  T
17**       23R0.3201                    57R0.0
           23R1.295                     57R0.0
           23R3.960                     57R0.0
           23R13.24                     57R0.0
           23R27.52                     57R0.0
           23R35.59                     57R0.0
           23R75.26                     57R0.0
           23R60.56                     57R0.0
           23R14.36                     57R0.0
           23R79.52                     57R0.0
           23R143.7                     57R0.0
           23R132.1                     57R0.0
           23R91.28                     57R0.0
           23R9.252                     57R0.0
                          640R0.0
           23R0.390                     57R0.0
           23R3.400                     57R0.0
           23R0.00                      57R0.0
           23R30.00                     57R0.0
           23R8.400E+04                 57R0.0
           23R6.600E+05                 57R0.0
           23R2.300E+07                 57R0.0
           23R2.600E+07                 57R0.0
           23R0.0                       57R0.0
           23R6.400E+08                 57R0.0
           23R2.800E+09                 57R0.0
           23R0.0                       57R0.0
           23R9.400E+09                 57R0.0
           23R5.500E+08                 57R0.0
           23R9.100E+08                 57R0.0
           23R1.100E+09                 57R0.0
           23R2.600E+09                 57R0.0
           23R1.100E+10                 57R0.0        T
3**        23R1.0      57R0.0    39Q80      T
1**        F0.0
4**        2210.0  3147.625  9148.895  5159.055  19162.865  2178.511
           1178.829  11180.099   278.829
5**        F1.0
6**        0.0  .0604938 .0453704 .0453704 .0604938 .0604938 .0453704
           .0453704 .0604938 0.00 .0453704 .0462962 .0453704 .0453704
           .0462962 .0453704 0.00 .0453704 .0453704 .0453704 .0453704
           0.00 .0604938 .0604938
7**        -.9759000 -.9511897 -.7867958 -.5773503 -.2182179 +.2182179
           +.5773503 +.7867958 +.9511897 -.8164965 -.7867958 -.5773503
           -.2182179 +.2182179 +.5773503 +.7867958 -.6172134 -.5773503
           -.2182179 +.2182179 +.5773503 -.3086067 -.2182179 +.21821
```

```
8$$    23R1    4R2    10R3    6R4    20R5    3R6    14R7
9$$     37      41     49      41     53      41     45

/  MAT    1 - H
/  MAT    5 - N
/  MAT    9 - O
/  MAT   13 - CR
/  MAT   17 - FE
/  MAT   21 - NI
/  MAT   25 - ZR
/  MAT   29 - U235
/  MAT   33 - U238
/
/ MIXTURE  37 - FUEL-RADIAL
/ MIXTURE  41 - STEEL
/ MIXTURE  45 - AIR
/ MIXTURE  49 - D-U238
/ MIXTURE  53 - WATER
/

10$$
/FUEL-RADIAL
     37  38  39  40
     37  38  39  40
     37  38  39  40
     37  38  39  40

/STEEL-
     41  42  43  44
     41  42  43  44
     41  42  43  44

/AIR-
     45  46  47  48
     45  46  47  48

/D-U238
     49  50  51  52
     49  50  51  52

/WATER
     53  54  55  56
     53  54  55  56

11$$
/ FUEL- RADIAL
      9  10  11  12
     25  26  27  28
     29  30  31  32
     33  34  35  36

/ STEEL-
     13  14  15  16
     17  18  19  20
     21  22  23  24

/ AIR-
      5   6   7   8
      9  10  11  12
```

```
/ D-U238
     29  30  31  32
     33  34  35  36

/WATER
      1   2   3   4
      9  10  11  12

12**
/ FUEL-RADIAL
          4R5.792E-3
          4R3.027E-3
          4R1.159E-4
          4R2.766E-3
/ STEEL
          4R1.767E-2
          4R6.213E-2
          4R7.620E-3
/ AIR
          4R1.98E-5
          4R5.28E-6
/D-U238
          4R1.0613E-4
          4R4.7528E-2

/WATER
          4R6.687E-2
          4R3.343E-2

19$$     F3
         T          T
```

Results for ZONE 6, ANISN output file IFRAD2.AO

GROUP	FLUX	F-D FACT	PRODUCT
1	3.670E-02	1.945E-01	7.137E-03
2	1.025E-01	1.597E-01	1.638E-02
3	2.505E-01	1.471E-01	3.683E-02
4	6.310E-01	1.477E-01	9.322E-02
5	1.016E+00	1.534E-01	1.559E-01
6	9.508E-01	1.506E-01	1.432E-01
7	1.349E+00	1.389E-01	1.875E-01
8	1.317E+00	1.284E-01	1.691E-01
9	4.031E-01	1.253E-01	5.050E-02
10	1.581E+00	1.263E-01	1.997E-01
11	2.852E+00	1.289E-01	3.677E-01
12	3.678E+00	1.169E-01	4.297E-01
13	4.962E+00	6.521E-02	3.236E-01
14	4.987E+00	9.188E-03	4.582E-02
15	2.211E+00	3.713E-03	8.209E-03
16	2.403E+00	4.009E-03	9.631E-03
17	1.874E+00	4.295E-03	8.048E-03
18	1.420E+00	4.476E-03	6.358E-03
19	1.853E+00	4.567E-03	8.463E-03
20	1.604E+00	4.535E-03	7.274E-03
21	1.668E+00	4.370E-03	7.290E-03
22	6.592E+01	3.714E-03	2.449E-01
23	3.396E+01	8.772E-03	2.979E-01
24	7.164E+01	7.478E-03	5.358E-01
25	3.432E+01	6.375E-03	2.188E-01
26	2.223E+01	5.414E-03	1.203E-01
27	2.911E+01	4.622E-03	1.346E-01
28	2.659E+01	3.960E-03	1.053E-01
29	6.296E+02	3.469E-03	2.184E+00
30	2.233E+02	3.019E-03	6.741E-01
31	2.338E+02	2.628E-03	6.142E-01
32	3.552E+02	2.205E-03	7.833E-01
33	2.722E+02	1.833E-03	4.988E-01
34	3.394E+02	1.523E-03	5.169E-01
35	5.440E+02	1.172E-03	6.379E-01
36	3.424E+02	8.759E-04	2.999E-01
37	4.319E+02	6.306E-04	2.723E-01
38	5.962E+02	3.834E-04	2.286E-01
39	5.030E+01	2.669E-04	1.343E-02
40	9.115E-02	9.348E-04	8.521E-05

The total dose outside zone 6 is 2.526E+00 mrem/hr neutron.
8.136E+00 mrem/hr gamma.

1.066E+01 mrem/hr total

```
IFRAD4.IF3.17BWR FA.35K BUP.2.65W% ENRI.3YR DECAY.RADIAL.N SHLD LOSS
15$$    1    0    3    8    2        1    0    5   80    0
       40    3    4   43   52       36    0   56    0    0
        1    0    0   20    0        0    0    0    5    0
        0    0    0    1    1        0
16**    2R0.0    0.0001   1.420892 381.00
        4R0.0    0.5000   0.0002   F0.0
        T
14*
 0 +30165- 9 0 +     0+ 0 0 +73389- 5 0 +51569- 639R+     0+ 0 0 +31936- 9
              ********* cross sections suppressed *********
 0 -41762- 4 0 -80478- 537R+    0+ 0 0 +53965- 4 0 -27670- 441R+    0+ 0
 0 +18099- 4 0 -15392- 438R+    0+ 0
  T
17**      23R0.3201                57R0.0
          23R1.295                 57R0.0
          23R3.960                 57R0.0
          23R13.24                 57R0.0
          23R27.52                 57R0.0
          23R35.59                 57R0.0
          23R75.26                 57R0.0
          23R60.56                 57R0.0
          23R14.36                 57R0.0
          23R79.52                 57R0.0
          23R143.7                 57R0.0
          23R132.1                 57R0.0
          23R91.28                 57R0.0
          23R9.252                 57R0.0
                        640R0.0
          23R0.390                 57R0.0
          23R3.400                 57R0.0
          23R0.00                  57R0.0
          23R30.00                 57R0.0
          23R8.400E+04             57R0.0
          23R6.600E+05             57R0.0
          23R2.300E+07             57R0.0
          23R2.600E+07             57R0.0
          23R0.0                   57R0.0
          23R6.400E+08             57R0.0
          23R2.800E+09             57R0.0
          23R0.0                   57R0.0
          23R9.400E+09             57R0.0
          23R5.500E+08             57R0.0
          23R9.100E+08             57R0.0
          23R1.100E+09             57R0.0
          23R2.600E+09             57R0.0
          23R1.100E+10             57R0.0
        T
3**     23R1.0     57R0.0   39Q80     T
1**     F0.0
4**     2210.0  3147.625  9148.895  5159.055  19162.865  2178.511
        1178.829  11180.099   278.829
5**     F1.0
6**     0.0  .0604938 .0453704 .0453704 .0604938 .0604938 .0453704
        .0453704 .0604938 0.00 .0453704 .0462962 .0453704 .0453704
        .0462962 .0453704 0.00 .0453704 .0453704 .0453704 .0453704
        0.00 .0604938 .0604938
7**     -.9759000 -.9511897 -.7867958 -.5773503 -.2182179 +.2182179
        +.5773503 +.7867958 +.9511897 -.8164965 -.7867958 -.5773503
        -.2182179 +.2182179 +.5773503 +.7867958 -.6172134 -.5773503
        -.2182179 +.2182179 +.5773503 -.3086067 -.2182179 +.2182179
```

```
8$$     23R1     4R2     10R3     6R4     37R5
9$$     37       41      49       41      45

/  MAT   1 - H
/  MAT   5 - N
/  MAT   9 - O
/  MAT  13 - CR
/  MAT  17 - FE
/  MAT  21 - NI
/  MAT  25 - ZR
/  MAT  29 - U235
/  MAT  33 - U238
/
/ MIXTURE  37 - FUEL-RADIAL
/ MIXTURE  41 - STEEL
/ MIXTURE  45 - AIR
/ MIXTURE  49 - D-U238
/ MIXTURE  53 - WATER
/

10$$
/FUEL-RADIAL
     37  38  39  40
     37  38  39  40
     37  38  39  40
     37  38  39  40

/STEEL-
     41  42  43  44
     41  42  43  44
     41  42  43  44

/AIR-
     45  46  47  48
     45  46  47  48

/D-U238
     49  50  51  52
     49  50  51  52

/WATER
     53  54  55  56
     53  54  55  56

11$$
/ FUEL- RADIAL
      9  10  11  12
     25  26  27  28
     29  30  31  32
     33  34  35  36

/ STEEL-
     13  14  15  16
     17  18  19  20
     21  22  23  24

/ AIR-
      5   6   7   8
      9  10  11  12
```

```
/ D-U238
      29  30  31  32
      33  34  35  36

/WATER
       1   2   3   4
       9  10  11  12

12**
/ FUEL-RADIAL
          4R5.792E-3
          4R3.027E-3
          4R1.159E-4
          4R2.766E-3
/ STEEL
          4R1.767E-2
          4R6.213E-2
          4R7.620E-3
/ AIR
          4R1.98E-5
          4R5.28E-6
/D-U238
          4R1.0613E-4
          4R4.7528E-2

/WATER
          4R6.687E-2
          4R3.343E-2

19$$      F3
          T          T
```

Results for ZONE 4. ANISN output file IFRAD4.AO

GROUP	FLUX	F-D FACT	PRODUCT
1	2.208E-01	1.945E-01	4.295E-02
2	6.626E-01	1.597E-01	1.058E-01
3	1.821E+00	1.471E-01	2.678E-01
4	5.264E+00	1.477E-01	7.776E-01
5	1.003E+01	1.534E-01	1.539E+00
6	1.134E+01	1.506E-01	1.708E+00
7	2.378E+01	1.389E-01	3.304E+00
8	2.515E+01	1.284E-01	3.230E+00
9	7.272E+00	1.253E-01	9.110E-01
10	4.026E+01	1.263E-01	5.085E+00
11	1.311E+02	1.289E-01	1.691E+01
12	9.629E+02	1.169E-01	1.125E+02
13	3.371E+03	6.521E-02	2.198E+02
14	8.109E+02	9.188E-03	7.450E+00
15	7.558E+01	3.713E-03	2.806E-01
16	1.110E+01	4.009E-03	4.451E-02
17	1.493E+00	4.295E-03	6.412E-03
18	2.258E-01	4.476E-03	1.011E-03
19	4.775E-02	4.567E-03	2.181E-04
20	8.000E-03	4.535E-03	3.629E-05
21	1.542E-03	4.370E-03	6.741E-06
22	1.574E-04	3.714E-03	5.847E-07
23	4.917E+00	8.772E-03	4.313E-02
24	6.255E+00	7.478E-03	4.678E-02
25	3.813E+00	6.375E-03	2.431E-02
26	4.733E+00	5.414E-03	2.562E-02
27	1.439E+01	4.622E-03	6.649E-02
28	3.015E+01	3.960E-03	1.194E-01
29	3.958E+02	3.469E-03	1.373E+00
30	4.235E+02	3.019E-03	1.279E+00
31	4.379E+02	2.628E-03	1.151E+00
32	9.849E+02	2.205E-03	2.172E+00
33	7.319E+02	1.833E-03	1.341E+00
34	7.939E+02	1.523E-03	1.209E+00
35	1.134E+03	1.172E-03	1.330E+00
36	6.442E+02	8.759E-04	5.643E-01
37	6.884E+02	6.306E-04	4.341E-01
38	4.587E+02	3.834E-04	1.759E-01
39	1.000E+01	2.669E-04	2.670E-03
40	3.628E-02	9.348E-04	3.391E-05

The total dose outside zone 4 is 3.740E+02 mrem/hr neutron.
1.136E+01 mrem/hr gamma.

3.854E+02 mrem/hr total

```
IFHEAD1.IF3.17BWR FA.35K BUP.2.65% ENRICH.3YR.TNZ SOURCE.CASK TOP HEAD
15$$    1    0    3    8    2         1    0    6   80    0
       40    3    4   43   44        36    0   52    0    0
        1    0    0   20    0         0    0    0    5    0
        0    0    0    1    1         0
16**    2R0.0     0.0001    1.420892 24.13
        4R0.0     0.5000    0.0002   F0.0
        T
14*
 0 +30165- 9 0 +     0+ 0 0 +73389- 5 0 +51569- 639R+     0+ 0 0 +31936- 9
                ********* cross sections suppressed *********
 0 -41762- 4 0 -80478- 537R+     0+ 0 0 +53965- 4 0 -27670- 441R+     0+ 0
 0 +18099- 4 0 -15392- 438R+     0+ 0
  T
17**  23R 1.185E-04      57R0.0
                 1680R0.0
      23R0.000E+00     57R0.0
      23R0.000E+00     57R0.0
      23R0.000E+00     57R0.0
      23R0.000E+00     57R0.0
      23R1.896E-19     57R0.0
      23R2.845E+00     57R0.0
      23R9.008E+02     57R0.0
      23R9.600E-01     57R0.0
      23R0.000E+00     57R0.0
      23R1.659E+08     57R0.0
      23R4.267E+06     57R0.0
      23R0.000E+00     57R0.0
      23R5.926E+06     57R0.0
      23R4.622E+06     57R0.0
      23R8.060E+05     57R0.0
      23R1.422E+05     57R0.0
      23R8.060E+05     57R0.0
      23R2.003E+07     57R0.0
        T
3**     23R1.0     57R0.0   39Q80      T
1**     F0.0
4**     2210.0  5143.750  4147.630  9148.90  21151.44
        1162.87  11164.14   262.87
5**     F1.0
6**     0.0   .0604938 .0453704 .0453704 .0604938 .0604938 .0453704
        .0453704 .0604938 0.00 .0453704 .0462962 .0453704 .0453704
        .0462962 .0453704 0.00 .0453704 .0453704 .0453704 .0453704
        0.00  .0604938 .0604938
7**     -.9759000 -.9511897 -.7867958 -.5773503 -.2182179 +.2182179
        +.5773503 +.7867958 +.9511897 -.8164965 -.7867958 -.5773503
        -.2182179 +.2182179 +.5773503 +.7867958 -.6172134 -.5773503
        -.2182179 +.2182179 +.5773503 -.3086067 -.2182179 +.2182179
8$$     23R1      6R2       5R3       10R4      22R5      14R6
9$$     37        45        41        49        41        45
```

```
/  MAT   1 = H
/  MAT   5 = N
/  MAT   9 = O
/  MAT  13 = CR
/  MAT  17 = FE
/  MAT  21 = NI
/  MAT  25 = ZR
/  MAT  29 = U235
/  MAT  33 = U238
/
/ MIXTURE  37 = TOP NOZ- RADIAL
/ MIXTURE  41 = STEEL
/ MIXTURE  45 = AIR
/ MIXTURE  49 = D-U238
/

10$$
/TOP NOZ-RADIAL
      37  38  39  40
      37  38  39  40
      37  38  39  40
      37  38  39  40

/STEEL-
      41  42  43  44
      41  42  43  44
      41  42  43  44

/AIR-
      45  46  47  48
      45  46  47  48

/D-U238
      49  50  51  52
      49  50  51  52

11$$
/ TOP NOZ- RADIAL
      13  14  15  16
      17  18  19  20
      21  21  22  23
      25  24  25  26

/ STEEL-
      13  14  15  16
      17  18  19  20
      21  22  23  24

/ AIR-
       5   6   7   8
       9  10  11  12

/ D-U238
      29  30  31  32
      33  34  35  36
```

```
12**
/ TOP NOZ-RADIAL
        4R2.203E-4
        4R7.745E-4
        4R9.501E-5
        4R1.832E-3

/ STEEL
        4R1.767E-2
        4R6.213E-2
        4R7.620E-3

/ AIR
        4R1.98E-5
        4R5.28E-6

/D-U238
        4R1.0613E-4
        4R4.7528E-2

19$$    F3
        T         T
```

Results for ZONE 5. ANISN output file ifheadl.ao

GROUP	FLUX	F-D FACT	PRODUCT
1	5.881E-05	1.945E-01	1.144E-05
2	4.677E-06	1.597E-01	7.469E-07
3	1.033E-06	1.471E-01	1.519E-07
4	1.702E-06	1.477E-01	2.514E-07
5	3.093E-06	1.534E-01	4.744E-07
6	3.542E-06	1.506E-01	5.334E-07
7	8.113E-06	1.389E-01	1.127E-06
8	7.973E-06	1.284E-01	1.024E-06
9	2.297E-06	1.253E-01	2.878E-07
10	1.443E-05	1.263E-01	1.823E-06
11	4.368E-05	1.289E-01	5.633E-06
12	1.012E-04	1.169E-01	1.183E-05
13	1.491E-04	6.521E-02	9.720E-06
14	2.721E-05	9.188E-03	2.500E-07
15	4.933E-06	3.713E-03	1.832E-08
16	1.930E-06	4.009E-03	7.737E-09
17	6.610E-07	4.295E-03	2.839E-09
18	2.313E-07	4.476E-03	1.035E-09
19	1.143E-07	4.567E-03	5.222E-10
20	3.570E-08	4.535E-03	1.619E-10
21	1.104E-08	4.370E-03	4.825E-11
22	1.382E-09	3.714E-03	5.131E-12
23	8.843E-07	8.772E-03	7.756E-09
24	3.210E-06	7.478E-03	2.400E-08
25	4.348E-06	6.375E-03	2.772E-08
26	5.270E-06	5.414E-03	2.853E-08
27	8.326E-06	4.622E-03	3.848E-08
28	1.568E-02	3.960E-03	6.208E-05
29	3.629E+00	3.469E-03	1.259E-02
30	2.063E+00	3.019E-03	6.228E-03
31	2.375E+00	2.628E-03	6.240E-03
32	6.655E+04	2.205E-03	1.467E+02
33	5.042E+04	1.833E-03	9.240E+01
34	6.444E+04	1.523E-03	9.813E+01
35	8.577E+04	1.172E-03	1.006E+02
36	5.136E+04	8.759E-04	4.499E+01
37	5.437E+04	6.306E-04	3.429E+01
38	3.498E+04	3.834E-04	1.341E+01
39	9.591E+02	2.669E-04	2.560E-01
40	2.052E+00	9.348E-04	1.918E-03

The total dose outside zone 5 is 4.532E-05 mrem/hr neutron.
5.308E+02 mrem/hr gamma.

5.308E+02 mrem/hr total

```
IF3AXI2,N.SEC GAM DOSE,35MWD/MTIHM,2.65W%,3YR DECAY,CASK TOP AXIAL
15$$   2     0    3   16    1          1    0    7  113    0
      40     3    4   43   88         36    0   60    0    0
       1     0    0   20    0          0    0    0    5    0
       0     0    0    1    1          0
16**   2R0.0     0.0001    1.420892 2R95.25
       3R0.0     0.5000    0.0002   F0.0
       T
14*
 0 +30165- 9 0 +    0+ 0 0 +73389- 5 0 +51569- 639R+    0+ 0 0 +31936- 9
             ********* cross sections suppressed *********
 0 -41762- 4 0 -80478- 537R+    0+ 0 0 +53965- 4 0 -27670- 441R+    0+ 0
 0 +18099- 4 0 -15392- 438R+    0+ 0
  T
17**    41R0.3201                72R0.0
        41R1.2950                72R0.0
        41R3.960                 72R0.0
        41R13.24                 72R0.0
        41R27.52                 72R0.0
        41R35.59                 72R0.0
        41R75.26                 72R0.0
        41R60.56                 72R0.0
        41R14.36                 72R0.0
        41R79.52                 72R0.0
        41R143.7                 72R0.0
        41R132.1                 72R0.0
        41R91.28                 72R0.0
        41R9.252                 72R0.0
                         904R0.0
        41R0.000                 72R0.0
                        1921R0.0
        T
3**     41R1.0     F0.0     T
1**     F0.0
4**     4010.0  191190.50  91238.19  41248.58  191251.12  61258.74
        91262.55   462.55
5**     F1.0
6**     0.0  .0244936 .0413296 .0392569 .0400796 .0643754 .0442097
        .1090850 .1371702 .1371702 .1090850 .0442097 .0643754
        .0400796 .0392569 .0413296 .0244936
7**     -.9902984 -.9805009 -.9092855 -.8319966 -.7467506 -.6504264
        -.5370966 -.3922893 -.1389568 +.1389568 +.3922893 +.5370966
        +.6504264 +.7467506 +.8319966 +.9092855 +.9805009
8$$     41R1     20R2     10R3      5R4     20R5      7R6     10R7
9$$      37       53       45       41       49       41       45
```

```
/  MAT    1 - H
/  MAT    5 - N
/  MAT    9 - O
/  MAT   13 - CR
/  MAT   17 - FE
/  MAT   21 - NI
/  MAT   25 - ZR
/  MAT   29 - U235
/  MAT   33 - U238
/
/ MIXTURE  37 - FUEL-AXIAL
/ MIXTURE  41 - STEEL
/ MIXTURE  45 - AIR
/ MIXTURE  49 - D-U238
/ MIXTURE  53 - TOP-NOZZLE
/ MIXTURE  57 - BOTTOM-NOZZLE
/

10$$
     37  38  39  40     37  38  39  40     37  38  39  40
     37  38  39  40     37  38  39  40     37  38  39  40
     37  38  39  40

     41  42  43  44     41  42  43  44     41  42  43  44

     45  46  47  48     45  46  47  48

     49  50  51  52     49  50  51  52

     53  54  55  56     53  54  55  56     53  54  55  56
     53  54  55  56

     57  58  59  60     57  58  59  60     57  58  59  60
     57  58  59  60

11$$
      9  10  11  12     13  14  15  16     17  18  19  20
     21  22  23  24     25  26  27  28     29  30  31  32
     33  34  35  36

     13  14  15  16     17  18  19  20     21  22  23  24

      5   6   7   8      9  10  11  12

     29  30  31  32     33  34  35  36

     13  14  15  16     17  18  19  20     21  22  23  24
     25  26  27  28

     13  14  15  16     17  18  19  20     21  22  23  24
     25  26  27  28
```

```
12**
        4R5.792E-3      4R7.306E-4      4R2.570E-3
        4R3.150E-4      4R3.027E-3      4R1.159E-4
        4R2.766E-3

        4R1.767E-2      4R6.213E-2      4R7.620E-2

        4R1.98E-5       4R5.28E-6

        4R1.0613E-4     4R4.7528E-2

        4R1.367E-3      4R4.807E-3      4R5.895E-4
        4R1.832E-3

        4R3.429E-3      4R1.206E-2      4R1.479E-3
        4R3.448E-4

19$$    F3         T          T
```

Results for ZONE 6, ANISN output file ifaxi2.ao

GROUP	FLUX	F-D FACT	PRODUCT
1	2.095E-02	1.945E-01	4.075E-03
2	6.421E-02	1.597E-01	1.025E-02
3	1.600E-01	1.471E-01	2.353E-02
4	4.063E-01	1.477E-01	6.002E-02
5	7.594E-01	1.534E-01	1.165E-01
6	8.215E-01	1.506E-01	1.237E-01
7	1.862E+00	1.389E-01	2.587E-01
8	2.296E+00	1.284E-01	2.949E-01
9	7.376E-01	1.253E-01	9.241E-02
10	5.011E+00	1.263E-01	6.330E-01
11	1.930E+01	1.289E-01	2.488E+00
12	1.440E+02	1.169E-01	1.683E+01
13	3.573E+02	6.521E-02	2.330E+01
14	6.587E+01	9.188E-03	6.052E-01
15	1.530E+01	3.713E-03	5.681E-02
16	6.047E+00	4.009E-03	2.424E-02
17	1.823E+00	4.295E-03	7.827E-03
18	4.332E-01	4.476E-03	1.939E-03
19	1.975E-01	4.567E-03	9.020E-04
20	6.142E-02	4.535E-03	2.786E-04
21	1.850E-02	4.370E-03	8.086E-05
22	2.460E-03	3.714E-03	9.139E-06
23	1.571E+00	8.772E-03	1.378E-02
24	1.196E+00	7.478E-03	8.946E-03
25	6.731E-01	6.375E-03	4.291E-03
26	5.420E-01	5.414E-03	2.934E-03
27	1.005E+00	4.622E-03	4.647E-03
28	1.020E+00	3.960E-03	4.037E-03
29	1.385E+00	3.469E-03	4.805E-03
30	1.356E+00	3.019E-03	4.093E-03
31	1.788E+00	2.628E-03	4.699E-03
32	2.391E+00	2.205E-03	5.272E-03
33	1.952E+00	1.833E-03	3.578E-03
34	2.378E+00	1.523E-03	3.621E-03
35	5.015E+00	1.172E-03	5.880E-03
36	2.715E+00	8.759E-04	2.378E-03
37	3.297E+00	6.306E-04	2.079E-03
38	2.128E+00	3.834E-04	8.157E-04
39	8.303E-02	2.669E-04	2.216E-05
40	4.672E-04	9.348E-04	4.368E-07

The total dose outside zone 6 is 4.493E+01 mrem/hr neutron.
7.588E-02 mrem/hr gamma.
\-------------------------
4.501E+01 mrem/hr total

```
IF3AXI4,N,SEC GAM DOSE,35MWD/MTIHM,2.65W%,3YR DECAY,CASK BOTTOM AXIAL
15$$    2     0     3    16     1          1     0     6   113     0
       40     3     4    43    88         36     0    60     0     0
        1     0     0    20     0          0     0     0     5     0
        0     0     0     1     1          0
16**    2R0.0      0.0001    1.420892 2R95.25
        3R0.0      0.5000    0.0002   F0.0
        T
14*
 0 +30165- 9 0 +    0+ 0 0 +73389- 5 0 +51569- 639R+    0+ 0 0 +31936- 9
               ********* cross sections suppressed *********
 0 -41762- 4 0 -80478- 537R+    0+ 0 0 +53965- 4 0 -27670- 441R+    0+ 0
 0 +18099- 4 0 -15392- 438R+    0+ 0
  T
17**     41R0.3201                  72R0.0
         41R1.2950                  72R0.0
         41R3.960                   72R0.0
         41R13.24                   72R0.0
         41R27.52                   72R0.0
         41R35.59                   72R0.0
         41R75.26                   72R0.0
         41R60.56                   72R0.0
         41R14.36                   72R0.0
         41R79.52                   72R0.0
         41R143.7                   72R0.0
         41R132.1                   72R0.0
         41R91.28                   72R0.0
         41R9.252                   72R0.0
                        904R0.0
         41R0.000                   72R0.0
                       1921R0.0
        T
3**     41R1.0     F0.0   T
1**     F0.0
4**     40I0.0  19I190.50  9I209.26  24I212.43  6I221.96  9I225.77
        425.77
5**     F1.0
6**     0.0  .0244936 .0413296 .0392569 .0400796 .0643754 .0442097
        .1090850 .1371702 .1371702 .1090850 .0442097 .0643754
        .0400796 .0392569 .0413296 .0244936
7**     -.9902984 -.9805009 -.9092855 -.8319966 -.7467506 -.6504264
        -.5370966 -.3922893 -.1389568 +.1389568 +.3922893 +.5370966
        +.6504264 +.7467506 +.8319966 +.9092855 +.9805009
8$$     41R1     20R2      10R3      25R4      7R5      10R6
9$$      37       57        41        49       41        45
```

```
/  MAT    1 - H
/  MAT    5 - N
/  MAT    9 - O
/  MAT   13 - CR
/  MAT   17 - FE
/  MAT   21 - NI
/  MAT   25 - ZR
/  MAT   29 - U235
/  MAT   33 - U238
/
/ MIXTURE  37 - FUEL-AXIAL
/ MIXTURE  41 - STEEL
/ MIXTURE  45 - AIR
/ MIXTURE  49 - D-U238
/ MIXTURE  53 - TOP-NOZZLE
/ MIXTURE  57 - BOTTOM-NOZZLE
/

10$$
      37  38  39  40      37  38  39  40      37  38  39  40
      37  38  39  40      37  38  39  40      37  38  39  40
      37  38  39  40

      41  42  43  44      41  42  43  44      41  42  43  44

      45  46  47  48      45  46  47  48

      49  50  51  52      49  50  51  52

      53  54  55  56      53  54  55  56      53  54  55  56
      53  54  55  56

      57  58  59  60      57  58  59  60      57  58  59  60
      57  58  59  60

11$$
       9  10  11  12      13  14  15  16      17  18  19  20
      21  22  23  24      25  26  27  28      29  30  31  32
      33  34  35  36

      13  14  15  16      17  18  19  20      21  22  23  24

       5   6   7   8       9  10  11  12

      29  30  31  32      33  34  35  36

      13  14  15  16      17  18  19  20      21  22  23  24
      25  26  27  28

      13  14  15  16      17  18  19  20      21  22  23  24
      25  26  27  28
```

12**

	4R5.792E-3 4R3.150E-4 4R2.766E-3	4R7.306E-4 4R3.027E-3	4R2.570E-3 4R1.159E-4
	4R1.767E-2	4R6.213E-2	4R7.620E-2
	4R1.98E-5	4R5.28E-6	
	4R1.0613E-4	4R4.7528E-2	
	4R1.367E-3 4R1.832E-3	4R4.807E-3	4R5.895E-4
	4R3.429E-3 4R3.448E-4	4R1.206E-2	4R1.479E-3
19$$	F3 T	T	

Results for ZONE 5, ANISN output file d:ifaxi4.ao

GROUP	FLUX	F-D FACT	PRODUCT
1	2.428E-02	1.945E-01	4.721E-03
2	7.079E-02	1.597E-01	1.131E-02
3	1.725E-01	1.471E-01	2.537E-02
4	4.281E-01	1.477E-01	6.325E-02
5	7.833E-01	1.534E-01	1.201E-01
6	8.330E-01	1.506E-01	1.255E-01
7	1.874E+00	1.389E-01	2.603E-01
8	2.334E+00	1.284E-01	2.998E-01
9	7.568E-01	1.253E-01	9.481E-02
10	5.281E+00	1.263E-01	6.670E-01
11	2.173E+01	1.289E-01	2.802E+00
12	2.113E+02	1.169E-01	2.469E+01
13	6.686E+02	6.521E-02	4.360E+01
14	1.270E+02	9.188E-03	1.167E+00
15	2.973E+01	3.713E-03	1.104E-01
16	1.177E+01	4.009E-03	4.717E-02
17	3.548E+00	4.295E-03	1.524E-02
18	8.436E-01	4.476E-03	3.776E-03
19	3.846E-01	4.567E-03	1.756E-03
20	1.235E-01	4.535E-03	5.601E-04
21	3.935E-02	4.370E-03	1.720E-04
22	5.374E-03	3.714E-03	1.996E-05
23	2.947E+00	8.772E-03	2.585E-02
24	2.278E+00	7.478E-03	1.703E-02
25	1.246E+00	6.375E-03	7.946E-03
26	9.727E-01	5.414E-03	5.266E-03
27	1.749E+00	4.622E-03	8.083E-03
28	1.780E+00	3.960E-03	7.047E-03
29	2.438E+00	3.469E-03	8.458E-03
30	2.339E+00	3.019E-03	7.062E-03
31	2.719E+00	2.628E-03	7.145E-03
32	3.775E+00	2.205E-03	8.323E-03
33	3.096E+00	1.833E-03	5.673E-03
34	3.762E+00	1.523E-03	5.729E-03
35	8.317E+00	1.172E-03	9.751E-03
36	4.429E+00	8.759E-04	3.880E-03
37	5.306E+00	6.306E-04	3.346E-03
38	3.408E+00	3.834E-04	1.306E-03
39	1.251E-01	2.669E-04	3.340E-05
40	7.421E-04	9.348E-04	6.937E-07

The total dose outside zone 5 is 7.411E+01 mrem/hr neutron.
1.319E-01 mrem/hr gamma.

7.424E+01 mrem/hr total

QAD-CGGP Input Deck for the Top Nozzle Model With 3 Year Fuel

```
QAD-CG IF-300 CASK 3YR FUEL TOP NOZZLE U GP BUILDUP ANSI F-TO-D
  15  30   30   6    5  99    7  99    0   2    1   0    0   0     0    0
3.399+05      0.0      0.0      0.0      0.0      0.0      0.0
 0.0 12.3 17.4 21.3 24.6 27.5 30.1 32.5
34.8 36.9 38.9 40.8 42.6 44.3 46.0 47.625
 190.5  192.1  193.7  195.3  196.8  198.4  200.0
 201.6  203.2  204.8  206.4  208.0  209.6  211.2
 212.7  214.3  215.9  217.5  219.1  220.7  222.2
 223.9  225.5  227.1  228.6  230.2  231.8  233.4
 235.0  236.6  238.2
0.0    0.1047 0.2094 0.3142 0.4189 0.5236 0.6283 0.7330
0.8378 0.9425 1.0472 1.1519 1.2566 1.3614 1.4661 1.5708
1.6755 1.7802 1.8850 1.9897 2.0944 2.1991 2.3038 2.4086
2.5133 2.6180 2.7227 2.8274 2.9322 3.0367 3.1416
   0    0           IF-300 BWR BASKET GEOMETRY
  RCC        0.0       0.0     -190.5        0.0        0.0      381.0
            47.63
  RCC        0.0       0.0      190.5        0.0        0.0       47.69
            47.63
  RCC        0.0       0.0      238.19       0.0        0.0       10.39
            47.63
  RCC        0.0       0.0     -209.26       0.0        0.0       18.76
            47.63
  RCC        0.0       0.0     -212.44       0.0        0.0      463.56
            48.89
  RCC        0.0       0.0     -221.97       0.0        0.0      480.71
            59.05
  RCC        0.0       0.0     -225.78       0.0        0.0      488.33
            62.86
  RPP     -800.0     800.0     -800.0      800.0     -800.0      800.0
  END
    1          +1
    2          +2
    3          +3
    4          +4
    5          +5       -1       -2       -3       -4
    6          +6       -5
    7          +7       -6
    8          +8       -7
  END
    1    2    3    4    5    6    7    8
    1    2 1000    3    4    5    4 1000
   99   8   24   26   28   40   92
URAN EXP
      0.154 0.063 0.238 0.031 0.458 1.138
      0.000 0.118 0.446 0.058 0.278 0.000
      0.000 0.296 1.118 0.144 0.052 0.000
      0.000 1.525 5.761 0.743 0.000 0.000
      0.000 0.000 0.000 0.000 0.000 18.82
  0.375 0.575 0.85  1.25  1.75  2.25  2.75
  3.9E+6  5.0E+6  3.6E+6  1.4E+8  8.1E+0  7.6E+2  2.4E+0
  .0008759   .0011725   .001833   .002205   .003019   .003469   .003960
  0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

0.3 - 3.0
0.3 - 0.4   0.4 - 0.6   0.8 - 1.0   1.0 - 1.3   1.7 - 2.0   2.0 - 2.5
2.5 - 3.0

PHOTONS/SEC/CM3		MREM/HR					W/G
0.0	262.6	0.0	1	0	0	0	
0.0	462.6	0.0	1	0	0	0	
0.0	762.6	0.0	1	0	0	0	
0.0	0.0	0.0	-1	0	0	0	

QAD-CG IF-300 CASK 3YR FUEL TOP NOZZLE U GP BURNUP.ANSI F-TO-D

RECEIVER NUMBER 1 COORDINATES - X 0.0000E-01 Y 0.0000E-01 Z 2.6260E+02

GRP NO	MEAN ENERGY MEV	ENERGY GROUP LIMITS MEV	DIRECT BEAM FLUX PHOTONS/SEC /CM3	MEAN BUILDUP FACTORS	DOSE RATE MREM/HR DIRECT BEAM	DOSE RATE MREM/HR WITH BUILDUP	HEATING RATES IN IRON W/G DIRECT BEAM	HEATING RATES IN IRON W/G WITH BUILDUP
TOTAL W/BU	1.2501 1.2501	0.3 - 3.0	8.4621E+02	3.6836E+00	1.8660E+00	6.8737E+00	0.0000E-01	0.0000E-01
1	0.3750	0.3 - 0.4	1.9050E-16	2.0427E+00	1.6686E-19	3.4084E-19	0.0000E-01	0.0000E-01
2	0.5750	0.4 - 0.6	1.4602E-05	2.6181E+00	1.7121E-08	4.4825E-08	0.0000E-01	0.0000E-01
3	0.8500	0.8 - 1.0	1.6599E-01	3.2187E+00	3.0426E-04	9.7931E-04	0.0000E-01	0.0000E-01
4	1.2500	1.0 - 1.3	8.4591E+02	3.6836E+00	1.8652E+00	6.8707E+00	0.0000E-01	0.0000E-01
5	1.7500	1.7 - 2.0	5.6104E-04	4.0649E+00	1.6938E-06	6.8850E-06	0.0000E-01	0.0000E-01
6	2.2500	2.0 - 2.5	1.3650E-01	4.3445E+00	4.7351E-04	2.0571E-03	0.0000E-01	0.0000E-01
7	2.7500	2.5 - 3.0	7.1884E-04	4.4169E+00	2.8466E-06	1.2573E-05	0.0000E-01	0.0000E-01

RECEIVER NUMBER 2 COORDINATES - X 0.0000E-01 Y 0.0000E-01 Z 4.6260E+02

GRP NO	MEAN ENERGY MEV	ENERGY GROUP LIMITS MEV	DIRECT BEAM FLUX PHOTONS/SEC /CM3	MEAN BUILDUP FACTORS	DOSE RATE MREM/HR DIRECT BEAM	DOSE RATE MREM/HR WITH BUILDUP	HEATING RATES IN IRON W/G DIRECT BEAM	HEATING RATES IN IRON W/G WITH BUILDUP
TOTAL W/BU	1.2501 1.2500	0.3 - 3.0	1.7706E+02	3.5811E+00	3.9044E-01	1.3982E+00	0.0000E-01	0.0000E-01
1	0.3750	0.3 - 0.4	8.9199E-17	2.0396E+00	7.8129E-20	1.5935E-19	0.0000E-01	0.0000E-01
2	0.5750	0.4 - 0.6	4.7965E-06	2.6047E+00	5.6239E-09	1.4648E-08	0.0000E-01	0.0000E-01
3	0.8500	0.8 - 1.0	4.2545E-02	3.1704E+00	7.7985E-05	2.4724E-04	0.0000E-01	0.0000E-01
4	1.2500	1.0 - 1.3	1.7700E+02	3.5811E+00	3.9028E-01	1.3976E+00	0.0000E-01	0.0000E-01
5	1.7500	1.7 - 2.0	1.0230E-04	3.8928E+00	3.0886E-07	1.2023E-06	0.0000E-01	0.0000E-01
6	2.2500	2.0 - 2.5	2.3385E-02	4.1082E+00	8.1123E-05	3.3327E-04	0.0000E-01	0.0000E-01
7	2.7500	2.5 - 3.0	1.1883E-04	4.1382E+00	4.7058E-07	1.9474E-06	0.0000E-01	0.0000E-01

QAD-CGGP Input Deck for the Active Fuel Model With 3 Year Fuel

```
QAD-CG IF-300 CASK 3 YR ACTIVE FUEL AXIAL U GP BUILDUP.ANSI F-TO-D
  15  34   30   6    5  99    8  99    0   1    1   0    0   0    0    0
2.715+06        0.0        0.0        0.0      0.0      0.0      0.0
 0.0 12.3 17.4 21.3 24.6 27.5 30.1 32.5
34.8 36.9 38.9 40.8 42.6 44.3 46.0 47.625
-190.5 -190.0 -189.0 -188.0 -187.0 -186.0 -185.0
-180.0 -175.0 -170.0 -160.0 -150.0 -140.0 -130.0
-120.0  -80.0  -40.0    0.0   40.0   80.0  120.0
 130.0  140.0  150.0  160.0  170.0  175.0  180.0
 185.0  186.0  187.0  188.0  189.0  190.0  190.5
0.0    0.1047 0.2094 0.3142 0.4189 0.5236 0.6283 0.7330
0.8378 0.9425 1.0472 1.1519 1.2566 1.3614 1.4661 1.5708
1.6755 1.7802 1.8850 1.9897 2.0944 2.1991 2.3038 2.4086
2.5133 2.6180 2.7227 2.8274 2.9322 3.0367 3.1416
   0     0          IF-300 BWR BASKET GEOMETRY
  RCC         0.0         0.0     -190.5        0.0         0.0     381.0
             47.63
  RCC         0.0         0.0      190.5        0.0         0.0      47.69
             47.63
  RCC         0.0         0.0      238.19       0.0         0.0      10.39
             47.63
  RCC         0.0         0.0     -209.26       0.0         0.0      18.76
             47.63
  RCC         0.0         0.0     -212.44       0.0         0.0     463.56
             48.89
  RCC         0.0         0.0     -221.97       0.0         0.0     480.71
             59.05
  RCC         0.0         0.0     -225.78       0.0         0.0     488.33
             62.86
  RPP      -800.0       800.0     -800.0      800.0      -800.0     800.0
  END
    1           +1
    2           +2
    3           +3
    4           +4
    5           +5       -1       -2       -3       -4
    6           +6       -5
    7           +7       -6
    8           +8       -7
  END
    1    2    3    4    5    6    7    8
    1    2 1000    3    4    5    4 1000
   99   8   24   26   28   40   92
URAN EXP
     0.154 0.063 0.238 0.031 0.458 1.138
     0.000 0.118 0.446 0.058 0.278 0.000
     0.000 0.296 1.118 0.144 0.052 0.000
     0.000 1.525 5.761 0.743 0.000 0.000
     0.000 0.000 0.000 0.000 0.000 18.82
  0.375 0.575 0.85   1.25   1.75   2.25   2.75   3.50
  5.5E+8  9.4E+9  2.8E+9  6.4E+8  2.6E+7  2.3E+7  6.6E+5  8.4E+4
  .0008759   .0011725   .001833   .002205   .003019   .003469
  .003960   .004622
```

```
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.3 - 4.0
0.3 - 0.4   0.4 - 0.6   0.8 - 1.0   1.0 - 1.3   1.7 - 2.0   2.0 - 2.5
2.5 - 3.0   3.0 - 4.0
PHOTONS/SEC/CM3          MREM/HR                 W/G
     0.0    262.6       0.0    1   0   0   0
     0.0   -225.8       0.0    1   0   0   0
     0.0    462.6       0.0    1   0   0   0
     0.0   -425.8       0.0    1   0   0   0
     0.0    762.6       0.0    1   0   0   0
     0.0   -725.8       0.0    1   0   0   0
     0.0      0.0       0.0   -1   0   0   0
```

QAD-CG IF-300 CASK 3 YR ACTIVE FUEL AXIAL U GP BUILDUP,ANSI F-TO-D

RECEIVER NUMBER 1 COORDINATES - X 0.0000E-01 Y 0.0000E-01 Z 2.6260E+02

GRP NO	MEAN ENERGY MEV	ENERGY GROUP LIMITS MEV	DIRECT BEAM FLUX PHOTONS/SEC /CM3	MEAN BUILDUP FACTORS	DOSE RATE MREM/HR DIRECT BEAM	DOSE RATE MREM/HR WITH BUILDUP	HEATING RATES IN IRON W/G DIRECT BEAM	HEATING RATES IN IRON W/G WITH BUILDUP
TOTAL	1.9462	0.3 - 4.0	4.6299E+02	4.7388E+00	1.4175E+00	6.7171E+00	0.0000E-01	0.0000E-01
W/BU	1.9058							
1	0.3750	0.3 - 0.4	5.9275E-17	2.0629E+00	5.1919E-20	1.0710E-19	0.0000E-01	0.0000E-01
2	0.5750	0.4 - 0.6	2.0530E-04	2.7068E+00	2.4071E-07	6.5155E-07	0.0000E-01	0.0000E-01
3	0.8500	0.8 - 1.0	2.2402E+00	3.4536E+00	4.1063E-03	1.4182E-02	0.0000E-01	0.0000E-01
4	1.2500	1.0 - 1.3	1.2355E+02	4.0552E+00	2.7243E-01	1.1048E+00	0.0000E-01	0.0000E-01
5	1.7500	1.7 - 2.0	8.4701E+01	4.5804E+00	2.5571E-01	1.1713E+00	0.0000E-01	0.0000E-01
6	2.2500	2.0 - 2.5	2.3704E+02	4.9897E+00	8.2230E-01	4.1030E+00	0.0000E-01	0.0000E-01
7	2.7500	2.5 - 3.0	1.2849E+01	5.1362E+00	5.0882E-02	2.6134E-01	0.0000E-01	0.0000E-01
8	3.5000	3.0 - 4.0	2.6084E+00	5.1904E+00	1.2056E-02	6.2575E-02	0.0000E-01	0.0000E-01

RECEIVER NUMBER 2 COORDINATES - X 0.0000E-01 Y 0.0000E-01 Z -2.2580E+02

GRP NO	MEAN ENERGY MEV	ENERGY GROUP LIMITS MEV	DIRECT BEAM FLUX PHOTONS/SEC /CM3	MEAN BUILDUP FACTORS	DOSE RATE MREM/HR DIRECT BEAM	DOSE RATE MREM/HR WITH BUILDUP	HEATING RATES IN IRON W/G DIRECT BEAM	HEATING RATES IN IRON W/G WITH BUILDUP
TOTAL	2.0437	0.3 - 4.0	1.1026E+02	5.3384E+00	3.5112E-01	1.8744E+00	0.0000E-01	0.0000E-01
W/BU	2.0045							
1	0.3750	0.3 - 0.4	4.5082E-21	2.1843E+00	3.9488E-24	8.6252E-24	0.0000E-01	0.0000E-01
2	0.5750	0.4 - 0.6	1.8218E-06	2.8049E+00	2.1361E-09	5.9915E-09	0.0000E-01	0.0000E-01
3	0.8500	0.8 - 1.0	1.4303E-01	3.6473E+00	2.6217E-04	9.5621E-04	0.0000E-01	0.0000E-01
4	1.2500	1.0 - 1.3	1.9560E+01	4.3455E+00	4.3129E-02	1.8742E-01	0.0000E-01	0.0000E-01
5	1.7500	1.7 - 2.0	2.0403E+01	5.0049E+00	6.1596E-02	3.0828E-01	0.0000E-01	0.0000E-01
6	2.2500	2.0 - 2.5	6.5565E+01	5.5737E+00	2.2745E-01	1.2677E+00	0.0000E-01	0.0000E-01
7	2.7500	2.5 - 3.0	3.7900E+00	5.8445E+00	1.5008E-02	8.7716E-02	0.0000E-01	0.0000E-01
8	3.5000	3.0 - 4.0	7.9577E-01	6.0719E+00	3.6781E-03	2.2333E-02	0.0000E-01	0.0000E-01

RECEIVER NUMBER 3 COORDINATES - X 0.0000E-01 Y 0.0000E-01 Z 4.6260E+02

GRP NO	MEAN ENERGY MEV	ENERGY GROUP LIMITS MEV	DIRECT BEAM FLUX PHOTONS/SEC /CM3	MEAN BUILDUP FACTORS	DOSE RATE MREM/HR DIRECT BEAM	DOSE RATE MREM/HR WITH BUILDUP	HEATING RATES IN IRON W/G DIRECT BEAM	HEATING RATES IN IRON W/G WITH BUILDUP
TOTAL W/BU	1.9130 1.8731	0.3 - 4.0	9.1166E+01	4.5664E+00	2.7539E-01	1.2575E+00	0.0000E-01	0.0000E-01
1	0.3750	0.3 - 0.4	3.0562E-17	2.0605E+00	2.6769E-20	5.5158E-20	0.0000E-01	0.0000E-01
2	0.5750	0.4 - 0.6	7.2607E-05	2.6915E+00	8.5132E-08	2.2914E-07	0.0000E-01	0.0000E-01
3	0.8500	0.8 - 1.0	5.9497E-01	3.4031E+00	1.0906E-03	3.7113E-03	0.0000E-01	0.0000E-01
4	1.2500	1.0 - 1.3	2.6996E+01	3.9655E+00	5.9527E-02	2.3606E-01	0.0000E-01	0.0000E-01
5	1.7500	1.7 - 2.0	1.6555E+01	4.4489E+00	4.9981E-02	2.2236E-01	0.0000E-01	0.0000E-01
6	2.2500	2.0 - 2.5	4.4219E+01	4.8181E+00	1.5339E-01	7.3907E-01	0.0000E-01	0.0000E-01
7	2.7500	2.5 - 3.0	2.3357E+00	4.9389E+00	9.2494E-03	4.5682E-02	0.0000E-01	0.0000E-01
8	3.5000	3.0 - 4.0	4.6526E-01	4.9625E+00	2.1504E-03	1.0672E-02	0.0000E-01	0.0000E-01

RECEIVER NUMBER 4 COORDINATES - X 0.0000E-01 Y 0.0000E-01 Z -4.2580E+02

GRP NO	MEAN ENERGY MEV	ENERGY GROUP LIMITS MEV	DIRECT BEAM FLUX PHOTONS/SEC /CM3	MEAN BUILDUP FACTORS	DOSE RATE MREM/HR DIRECT BEAM	DOSE RATE MREM/HR WITH BUILDUP	HEATING RATES IN IRON W/G DIRECT BEAM	HEATING RATES IN IRON W/G WITH BUILDUP
TOTAL W/BU	2.0094 1.9714	0.3 - 4.0	2.4805E+01	5.0860E+00	7.7990E-02	3.9665E-01	0.0000E-01	0.0000E-01
1	0.3750	0.3 - 0.4	1.3184E-21	2.1541E+00	1.1548E-24	2.4874E-24	0.0000E-01	0.0000E-01
2	0.5750	0.4 - 0.6	7.0756E-07	2.7963E+00	8.2962E-10	2.3198E-09	0.0000E-01	0.0000E-01
3	0.8500	0.8 - 1.0	4.5134E-02	3.6107E+00	8.2731E-05	2.9871E-04	0.0000E-01	0.0000E-01
4	1.2500	1.0 - 1.3	5.1099E+00	4.2524E+00	1.1267E-02	4.7914E-02	0.0000E-01	0.0000E-01
5	1.7500	1.7 - 2.0	4.6575E+00	4.8323E+00	1.4061E-02	6.7946E-02	0.0000E-01	0.0000E-01
6	2.2500	2.0 - 2.5	1.4050E+01	5.3178E+00	4.8740E-02	2.5919E-01	0.0000E-01	0.0000E-01
7	2.7500	2.5 - 3.0	7.8278E-01	5.5234E+00	3.0998E-03	1.7122E-02	0.0000E-01	0.0000E-01
8	3.5000	3.0 - 4.0	1.5992E-01	5.6616E+00	7.3913E-04	4.1846E-03	0.0000E-01	0.0000E-01

RECEIVER NUMBER 5 COORDINATES - X 0.0000E-01 Y 0.0000E-01 Z 7.6260E+02

GRP NO	MEAN ENERGY MEV	ENERGY GROUP LIMITS MEV	DIRECT BEAM FLUX PHOTONS/SEC /CM3	MEAN BUILDUP FACTORS	DOSE RATE MREM/HR DIRECT BEAM	DOSE RATE MREM/HR WITH BUILDUP	HEATING RATES IN IRON W/G DIRECT BEAM	HEATING RATES IN IRON W/G WITH BUILDUP
TOTAL	1.9107	0.3 - 4.0	2.3090E+01	4.5561E+00	6.9680E-02	3.1747E-01	0.0000E-01	0.0000E-01
W/BU	1.8707							
1	0.3750	0.3 - 0.4	9.3887E-18	2.0593E+00	8.2235E-21	1.6934E-20	0.0000E-01	0.0000E-01
2	0.5750	0.4 - 0.6	1.9792E-05	2.6883E+00	2.3206E-08	6.2384E-08	0.0000E-01	0.0000E-01
3	0.8500	0.8 - 1.0	1.5494E-01	3.3966E+00	2.8400E-04	9.6466E-04	0.0000E-01	0.0000E-01
4	1.2500	1.0 - 1.3	6.8871E+00	3.9577E+00	1.5186E-02	6.0102E-02	0.0000E-01	0.0000E-01
5	1.7500	1.7 - 2.0	4.1877E+00	4.4404E+00	1.2643E-02	5.6139E-02	0.0000E-01	0.0000E-01
6	2.2500	2.0 - 2.5	1.1155E+01	4.8092E+00	3.8695E-02	1.8609E-01	0.0000E-01	0.0000E-01
7	2.7500	2.5 - 3.0	5.8847E-01	4.9304E+00	2.3303E-03	1.1489E-02	0.0000E-01	0.0000E-01
8	3.5000	3.0 - 4.0	1.1713E-01	4.9544E+00	5.4139E-04	2.6823E-03	0.0000E-01	0.0000E-01

RECEIVER NUMBER 6 COORDINATES - X 0.0000E-01 Y 0.0000E-01 Z -7.2580E+02

GRP NO	MEAN ENERGY MEV	ENERGY GROUP LIMITS MEV	DIRECT BEAM FLUX PHOTONS/SEC /CM3	MEAN BUILDUP FACTORS	DOSE RATE MREM/HR DIRECT BEAM	DOSE RATE MREM/HR WITH BUILDUP	HEATING RATES IN IRON W/G DIRECT BEAM	HEATING RATES IN IRON W/G WITH BUILDUP
TOTAL	2.0062	0.3 - 4.0	5.6164E+00	5.0660E+00	1.7634E-02	8.9334E-02	0.0000E-01	0.0000E-01
W/BU	1.9679							
1	0.3750	0.3 - 0.4	4.0799E-22	2.1583E+00	3.5736E-25	7.7131E-25	0.0000E-01	0.0000E-01
2	0.5750	0.4 - 0.6	1.8183E-07	2.7918E+00	2.1320E-10	5.9520E-10	0.0000E-01	0.0000E-01
3	0.8500	0.8 - 1.0	1.0750E-02	3.6012E+00	1.9705E-05	7.0961E-05	0.0000E-01	0.0000E-01
4	1.2500	1.0 - 1.3	1.1748E+00	4.2394E+00	2.5904E-03	1.0982E-02	0.0000E-01	0.0000E-01
5	1.7500	1.7 - 2.0	1.0544E+00	4.8167E+00	3.1834E-03	1.5333E-02	0.0000E-01	0.0000E-01
6	2.2500	2.0 - 2.5	3.1647E+00	5.2995E+00	1.0978E-02	5.8179E-02	0.0000E-01	0.0000E-01
7	2.7500	2.5 - 3.0	1.7589E-01	5.5039E+00	6.9652E-04	3.8335E-03	0.0000E-01	0.0000E-01
8	3.5000	3.0 - 4.0	3.5878E-02	5.6405E+00	1.6583E-04	9.3536E-04	0.0000E-01	0.0000E-01

QAD-CGGP Input Deck for the Bottom Nozzle Model With 3 Year Fuel

```
QAD-CG IF-300 CASK 3YR FUEL BOT NOZZLE U GP BUILDUP.ANSI F-TO-D
  15  30    30    6     5  99     7  99     0   4     1   0     0   0     0   0
1.337+05       0.0         0.0        0.0        0.0        0.0        0.0
 0.0 12.3 17.4 21.3 24.6 27.5 30.1 32.5
34.8 36.9 38.9 40.8 42.6 44.3 46.0 47.625
-209.3 -208.6 -208.0 -207.4 -206.7 -206.1 -205.5
-204.9 -204.3 -203.6 -203.0 -202.4 -201.8 -201.1
-200.5 -199.9 -199.3 -198.6 -198.0 -197.4 -196.7
-196.1 -195.5 -194.9 -194.3 -193.6 -193.0 -192.4
-191.7 -191.1 -190.5
0.0    0.1047 0.2094 0.3142 0.4189 0.5236 0.6283 0.7330
0.8378 0.9425 1.0472 1.1519 1.2566 1.3614 1.4661 1.5708
1.6755 1.7802 1.8850 1.9897 2.0944 2.1991 2.3038 2.4086
2.5133 2.6180 2.7227 2.8274 2.9322 3.0367 3.1416
   0     0           IF-300 BWR BASKET GEOMETRY
 RCC        0.0       0.0      -190.5       0.0        0.0      381.0
           47.63
 RCC        0.0       0.0       190.5       0.0        0.0       47.69
           47.63
 RCC        0.0       0.0       238.19      0.0        0.0       10.39
           47.63
 RCC        0.0       0.0      -209.26      0.0        0.0       18.76
           47.63
 RCC        0.0       0.0      -212.44      0.0        0.0      463.56
           48.89
 RCC        0.0       0.0      -221.97      0.0        0.0      480.71
           59.05
 RCC        0.0       0.0      -225.78      0.0        0.0      488.33
           62.86
 RPP     -800.0     800.0      -800.0     800.0     -800.0      800.0
 END
   1           +1
   2           +2
   3           +3
   4           +4
   5           +5     -1      -2      -3      -4
   6           +6     -5
   7           +7     -6
   8           +8     -7
 END
   1    2    3    4    5    6    7    8
   1    2 1000    3    4    5    4 1000
  99    8   24   26   28   40   92
URAN EXP
      0.154 0.063 0.238 0.031 0.458 1.138
      0.000 0.118 0.446 0.058 0.278 0.000
      0.000 0.296 1.118 0.144 0.052 0.000
      0.000 1.525 5.761 0.743 0.000 0.000
      0.000 0.000 0.000 0.000 0.000 18.82
  0.375 0.575 0.85  1.25  1.75  2.25  2.75
  3.7E+4  4.9E+3  1.5E+7  9.0E+8  5.1E+1  4.8E+3  1.5E+01
  .0008759  .0011725  .001833  .002205  .003019  .003469  .003960
  0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

0.3 - 3.0
0.3 - 0.4   0.4 - 0.6   0.8 - 1.0   1.0 - 1.3   1.7 - 2.0   2.0 - 2.5
2.5 - 3.0

PHOTONS/SEC/CM3		MREM/HR					W/G
0.0	-225.8	0.0	1	0	0	0	
0.0	-425.8	0.0	1	0	0	0	
0.0	-725.8	0.0	1	0	0	0	
0.0	0.0	0.0	-1	0	0	0	

QAD-CG IF-300 CASK 3YR FUEL BOT NOZZLE U GP BUILDUP,ANSI F-TO-D

RECEIVER NUMBER 1 COORDINATES - X 0.0000E-01 Y 0.0000E-01 Z -2.2580E+02

GRP NO	MEAN ENERGY MEV	ENERGY GROUP LIMITS MEV	DIRECT BEAM FLUX PHOTONS/SEC /CM3	MEAN BUILDUP FACTORS	DOSE RATE DIRECT BEAM MREM/HR	DOSE RATE WITH BUILDUP MREM/HR	HEATING RATES IN IRON DIRECT BEAM W/G	HEATING RATES IN IRON WITH BUILDUP W/G
TOTAL	1.2503	0.3 - 3.0	2.1869E+02	4.0531E+00	4.8228E-01	1.9547E+00	0.0000E-01	0.0000E-01
W/BU	1.2503							
1	0.3750	0.3 - 0.4	3.8550E-24	2.1076E+00	3.3766E-27	7.1165E-27	0.0000E-01	0.0000E-01
2	0.5750	0.4 - 0.6	1.9472E-11	2.7649E+00	2.2831E-14	6.3124E-14	0.0000E-01	0.0000E-01
3	0.8500	0.8 - 1.0	9.7699E-03	3.5024E+00	1.7908E-05	6.2722E-05	0.0000E-01	0.0000E-01
4	1.2500	1.0 - 1.3	2.1861E+02	4.0527E+00	4.8204E-01	1.9535E+00	0.0000E-01	0.0000E-01
5	1.7500	1.7 - 2.0	2.2543E-04	4.5380E+00	6.8057E-07	3.0885E-06	0.0000E-01	0.0000E-01
6	2.2500	2.0 - 2.5	6.4175E-02	4.9385E+00	2.2262E-04	1.0994E-03	0.0000E-01	0.0000E-01
7	2.7500	2.5 - 3.0	3.5982E-04	5.0926E+00	1.4249E-06	7.2563E-06	0.0000E-01	0.0000E-01

RECEIVER NUMBER 2 COORDINATES - X 0.0000E-01 Y 0.0000E-01 Z -4.2580E+02

GRP NO	MEAN ENERGY MEV	ENERGY GROUP LIMITS MEV	DIRECT BEAM FLUX PHOTONS/SEC /CM3	MEAN BUILDUP FACTORS	DOSE RATE DIRECT BEAM MREM/HR	DOSE RATE WITH BUILDUP MREM/HR	HEATING RATES IN IRON DIRECT BEAM W/G	HEATING RATES IN IRON WITH BUILDUP W/G
TOTAL	1.2503	0.3 - 3.0	4.8513E+01	3.9607E+00	1.0698E-01	4.2373E-01	0.0000E-01	0.0000E-01
W/BU	1.2502							
1	0.3750	0.3 - 0.4	3.7641E-24	2.0956E+00	3.2970E-27	6.9090E-27	0.0000E-01	0.0000E-01
2	0.5750	0.4 - 0.6	7.8393E-12	2.7429E+00	9.1916E-15	2.5211E-14	0.0000E-01	0.0000E-01
3	0.8500	0.8 - 1.0	2.6877E-03	3.4495E+00	4.9266E-06	1.6994E-05	0.0000E-01	0.0000E-01
4	1.2500	1.0 - 1.3	4.8498E+01	3.9604E+00	1.0694E-01	4.2352E-01	0.0000E-01	0.0000E-01
5	1.7500	1.7 - 2.0	4.4124E-05	4.3872E+00	1.3321E-07	5.8442E-07	0.0000E-01	0.0000E-01
6	2.2500	2.0 - 2.5	1.1905E-02	4.7242E+00	4.1297E-05	1.9510E-04	0.0000E-01	0.0000E-01
7	2.7500	2.5 - 3.0	6.4768E-05	4.8302E+00	2.5648E-07	1.2389E-06	0.0000E-01	0.0000E-01

A-6.0 CRITICALITY EVALUATION

This chapter describes the engineering/physics design elements of the IF-300 Channelled BWR Fuel Basket which are important to safety and necessary to comply with the performance requirements specified in Sections 71.55 and 71.57 of 10 CFR Part 71 [A-6.6.1-1].

The results of detailed analyses are presented which demonstrate that the IF-300 Channelled BWR Fuel Basket is critically safe under normal and accident conditions, considering a variety of mechanical uncertainties. Sufficient detail has been included herein to permit reviewers to accomplish an independent evaluation of the criticality analyses. Much of this detail is available in Section A-6.6.3 in which computer inputs and outputs have been provided for review.

A-6.1 Discussion and Results

A-6.1.1 IF-300 Channelled BWR Fuel Basket Design Features

The IF-300 Channelled BWR Fuel Basket is designed to provide criticality control through a combination of mechanical and neutronic isolation of fuel assemblies. A support structure composed of four axially oriented support rods and nine spacer disks provides positive location for the fuel assemblies under both normal and accident conditions. The basket assembly utilizes fixed neutron absorbers which effectively isolate pairs of fuel assemblies.

After performing a study of the available neutron absorbers, NeutroSorb Plus™ [1] was chosen due to its desirable neutron attenuation, homogeneity, corrosion resistance, strength, and toughness. Commercial experience with NeutroSorb Plus™ includes a wide range of applications including the TN-REG and TN-BRP transport/storage casks, Indian Point fuel storage racks, and scram balls in British Magnox reactors.

NeutroSorb Plus™ is a modified Type 304 austenitic chrome-nickel stainless steel which can be supplied with boron additions up to 2% to provide thermal neutron absorbtion. A standard specification for borated stainless steels denoted ASTM A887-88 [A-6.6.1-2] has been approved by the American Society for Testing and Materials (ASTM). Neutrosorb Plus™ is

[1] NeutroSorb Plus™, is manufactured by Carpenter Technology Corporation, Reading, Pennsylvania.

manufactured to the ASTM A887 specification using powder metallurgy techniques which have been shown to exhibit better mechanical properties and homogeneity than conventional cast/wrought products (such as NeutroSorb™), B_4C/Al aggregate products (such as Boral®), or coatings. Experimental analysis of the boride distribution in NeutroSorb Plus™ has shown boride lengths in the 2 μm range with corresponding mean boride spacings in the 10 μm range.

The material is available with either natural boron or isotopically enriched B-10. An isotopically enriched alloy was chosen for the IF-300 Channelled BWR Fuel Basket for two advantages. The isotopically enriched NeutroSorb Plus™ has better absorption qualities which allows for fewer plates in the basket. Fewer plates results in less potential for crud traps and a corresponding decrease in occupational exposure. Specifying enriched boron also allows the plates to have a lower boron content, significantly improving the mechanical properties.

Although this material would be an effective load bearing component in the basket assembly, the IF-300 Channelled BWR Fuel Basket has been designed such that the neutron absorbers are in no way loaded by other package components. The absorber sheets are supported in stainless steel channels which are conventionally welded to the spacer disks. As a result, the sheets are captured such that no welding or bending is performed on them.

The material properties assumed for the criticality analysis are:

Finished plate thickness	0.250", +0.045"/-0.010"
SS304 "Skin" thickness	0.007" maximum, each side
Boron content	1.0 w/o minimum
B-10 enrichment	94% (by atoms) B-10, min
Plate density	7.76 g/cc minimum

The principal performance features of the IF-300 Channelled BWR Fuel Basket as they relate to criticality control are:

- The package is designed such that it would be subcritical if water were to leak into or out of the containment system.
- The criticality analyses have been performed with consideration for

- the most reactive credible configuration consistent with the chemical and physical form of the fuel,

- moderation by water to the most reactive credible extent,

- close reflection by water on all sides,

- Any number of undamaged, or damaged (10CFR71.73) packages will remain subcritical in any arrangement with close water reflection and optimum interspersed hydrogenous moderation.

A-6.1.2 Criticality Analysis Summary and Results

The calculated maximum k_{eff} for the IF-300 Channelled BWR Fuel Basket is 0.922 including all biases and uncertainties applicable to the calculational methodology and the design.

The criticality analysis was performed in accordance with the requirements of:

- ANSI/ANS-8.1-1983, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors" [A-6.6.1-3].

- ANSI/ANS-8.17-1984, "Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors" [A-6.6.1-4].

- USNRC Regulatory Guide 3.41, Validation of Calculational Methods for Nuclear Criticality Safety," Revision 1, May, 1977 [A-6.6.1-5].

- ANSI N16.9-1975, "Validation of Calculational Methods for Nuclear Criticality Safety" [A-6.6.1-6].

Guidance has been taken from USNRC Regulatory Guide 1.13, "Spent Fuel Storage Facility Design Basis," Proposed Revision 2, December 1981 [A-6.6.1-7], as it applies to the calculation of k_{eff} for a transportation cask.

A-6.2 Package Fuel Loading

A-6.2.1 Maximum Loading

Prior to 1991, the IF-300 Cask was licensed for transport of up to seven PWR or eighteen BWR irradiated fuel assemblies [A-6.6.1-8].

The IF-300 Channelled BWR Fuel Basket is designed to accommodate up to seventeen irradiated BWR fuel assemblies, with the flow channels, spacers, and fasteners intact.

The maximum fuel enrichment is 4.0 w/o U235 which is unchanged from the Certificate of Compliance for the existing dechannelled BWR fuel basket [A-6.6.1-8]. Since no credit for burnup or burnable poisons is assumed in the criticality calculations, unirradiated fuel is qualified for shipment.

The maximum fuel loading parameters as they relate to criticality are summarized in Table A-6.2-1.

A-6.2.2 <u>Qualified Fuel Types</u>

The current spectrum of GE BWR fuel designs spans six BWR reactor designs, three classes of reactor core configurations, and nine major fuel design evolutions [A-6.6.1-9 and 10]. At least 26 unique fuel designs are in service; many with their own variants. In order to maximize the number of specific fuel designs which may be demonstrated to be safely shipped in the IF-300 Channelled BWR Fuel Basket, the criticality analyses are performed using a bounding reference fuel assembly.

The reference BWR fuel design for criticality is chosen based on a criticality analysis of several candidate BWR fuel types. The results of the analysis indicate that, while all fuel designs examined were equivalent within the 95% confidence levels of the KENO-IV [A-6.6.1-11] runs, the General Electric fuel design designated GE-3, V2b [A-6.6.1-9] (commonly referred to as GE 7x7) is slightly more reactive at the representative assembly pitch of 6.77" than the other designs. This assembly is therefore chosen as the reference assembly.

The list of fuel types qualified for shipment is shown in Table A-6.2-2. These fuel designs are bounded by or equivalent to the reference fuel design in terms of their reactivity. There is therefore no restriction on mixing different fuel designs within a single shipment.

Fuels which have peak enrichments higher than the design basis, or fuels which are not included in the list of qualified fuel types may be acceptable for shipment pending qualification calculations and a license amendment.

The design properties of the reference fuel are given in Table A-6.2-3.

Table A-6.2-1

Maximum Fuel Loading Parameters

Parameter	Value
Number of Assemblies	≤ 17
Enrichment, w/o U235	≤4.0%
Minimum Burnup	0
Fuel Design	See Table A-6.2-2
Fuel Channels	Intact

Table A-6.2-2

Qualified Fuel Designs

Fuel Design [A-6.1.1-9]	Reactor Class
GE 7x7 GE-3, V1	GE BWR/2,3
GE 7x7 GE-3, V2a	GE BWR/4,5,6
GE 7x7 GE-3, V2b	GE BWR/4,5,6
GE 8x8 GE-4, V1	GE BWR/2,3
GE 8x8 GE-4, V2a	GE BWR/4,5,6
GE 8x8 GE-4, V2b	GE BWR/4,5,6
GE 8x8 GE-5, V1	GE BWR/2,3
GE 8x8 GE-5, V2	GE BWR/4,5,6
GE 8x8 Press., V1	GE BWR/2,3
GE 8x8 Press., V2	GE BWR/4,5,6
GE 8x8 Barrier, V1	GE BWR/2,3
GE 8x8 Barrier, V2	GE BWR/4,5,6
GE 8x8 Barrier, V1a	GE BWR/2,3
GE 8x8 Barrier, V1b	GE BWR/2,3
GE 8x8 Barrier, V2a	GE BWR/4,5,6
GE 8x8 Barrier, V2b	GE BWR/4,5,6

Table A-6.2-3

Design Basis Fuel Parameters
for Criticality Analysis

Parameter	Value
Fuel Pellet Outside Diameter	0.477"
Fuel Clad Inside Diameter	0.489"
Fuel Clad Outside Diameter	0.563"
Fuel Rod Pitch	0.738"
Active Fuel Height	146.0"
Flow Channel Outside Diameter	5.454"
Flow Channel Thickness	0.080"
Enrichment, w/o U235	4.0%
U02 Density, %Theoretical Dens.	95.0%
Rod Array (N x N Rods)	7
Rod Locations	49
Fueled Rod Locations	49

A-6.3 Model Specification

A-6.3.1 Description of Calculational Model

The nominal calculational model was generated using the generalized geometry feature of KENO-IV [A-6.6.1-11] and homogeneous fuel cross sections. The model is described in detail below and in Section A-6.6.3. Additional rod-by-rod (heterogeneous cross sections) KENO models are used to calculate the effects of various biases and uncertainties. Those models are described in Section A-6.3.1.2 and in Section A-6.6.3.

1. Nominal Cask Model

The nominal cask model is quarter-symmetric and surrounded on all six sides by 100% specular albedo conditions, resulting in a representation of an infinite square array of flooded, immersed IF-300 casks containing infinitely long fuel assemblies. It is assumed that this is conservative since an array of infinitely long casks is more reactive than layers of arrays of finite length casks. This method is therefore assumed to satisfy the requirements of 10CFR71.57 regarding subcriticality of an unlimited number of packages.

The model is illustrated in Figure A-6.3-1 which is a schematic diagram indicating the material regions included in the model. The model dimensions are available in the KENO-IV input files located in Section A-6.6.3.1. Figure A-6.3-2 is a more detailed diagram of the cask model. It shows the various blocks, surfaces, and sectors as an aid for reviewing the input files.

Several assumptions are necessary in order to create the quarter-cask model. The items which are explicitly included in the model are: homogenized fuel assemblies with their surrounding fuel channels, the IF-300 Cask walls, the basket support rods, the poison plates, and a water region surrounding the cask. Some items are not included in the model, and a discussion of these omitted items follows.

The spacer disks are not included in the model. This modeling approach is conservative since spacer disks produce a localized region where the interassembly moderator is significantly reduced. It is assumed that this reduction would result in a locally undermoderated situation that would have a negative impact on k_{eff}. In parallel, steel has

a higher absorbtion cross section than water and therefore more neutrons are lost to absorbtion in the real system than in the cask model. Beirman [A-6.6.1-12] concluded that thick steel walls are a better reflector than water alone, and that thin sheets tended to act as a poison. Although these conclusions are regarding full length reflecting walls, not a spacer disk geometry, it is reasonable to assume that the spacer disks, which form a lattice in and around the assemblies, would tend to poison the system.

The fuel assembly plenum, top and bottom fitting regions, and the cask top and bottom regions are not modeled in the quarter cask model. It is assumed that an infinitely long fuel assembly provides better neutron reflection upon itself than the real system will.

The IF-300 Channelled BWR Fuel Basket design does not have neutron absorbers running continuously along the axis of the cask. Channels fastened to the spacer disks are employed to hold the absorber panels in place. No poison runs through the thickness of the spacer disk. The KENO model, however, does not model the spacer disks and therefore does not model the discontinuities in the absorber sheets. The impact on cask reactivity is difficult to estimate by observation alone, although it should tend to offset the favorable bias imposed by neglecting spacer disks.

Due to the difficulty in establishing whether the cask modeling technique (particularly the treatment of the discontinuous absorber sheets) is conservative, infinite arrays are modeled with continuous poison sheets and no spacer disks (similar to the quarter cask model), and with spacer disks, segmented poison sheets, and axial reflectors (similar to the actual cask geometry). The results are discussed below.

The channels which hold the absorber sheets in place are not modeled. This should have negligible impact on the results since the volume of the channels is small, and since they should have a negative effect on the reactivity similar to the spacer disks as discussed above.

2. Other Models

Three infinite array KENO models were created in order to perform the required sensitivity analyses. They are used for the moderator temperature/density study, the spacer disk study, and the rod pitch study respectively. The moderator temperature/density study model is also used for the neutron absorber sheet thickness study and the baseline case.

The assembly cell pitch on all infinite array calculations is specified as 6.77" by 7.22" which is the assembly pitch of the most neutronically important assembly in the basket geometry (central assembly). In addition, two neutron absorber plates are present in each infinite array model in order to more closely simulate the basket.

The baseline case is run using the model shown in Figure A-6.3-3. It is a straightforward infinite array model which includes the reference assembly, a water layer, the fuel channel, another water layer, and a layer of neutron poison on two opposing sides of the assembly. Details of the model are included in Section A-6.6.3. The conditions specified in this model are:

Moderator temperature	20°C
Moderator density	0.998230 g/cc
Rod Pitch	0.738 in
Absorber thickness	0.25 in

The spacer disk model is constructed from alternating layers of the blocks shown in Figure A-6.3-4 and Figure A-6.3-5. Blocks 1 through 20 represent the axial portion of the fuel which is located in between the spacer disks. The thickness of these blocks is 18.15". The remaining blocks 21 through 40 represent the spacer disks. Their height is 2 inches and the materials are identical to blocks 1 through 20 except that the outermost blocks are steel. The materials are indicated in Figure A-6.3-5. The eight disks and seven inter-disk regions within the active fuel region are modeled.

Axial reflector regions are specified above and below the core in order to approximate the cask and fuel end zones. From bottom to top, the regions are: 3.75 inches of depleted uranium, 7.5 inches of end fitting (KENO mixture #7, modeled as steel/water at a 50/50 volume ratio), the core, 24 inches of end fitting (again, mixture #7), and 3

inches of depleted uranium. Specular albedo conditions are specified on the top and bottom to represent an infinite stack of casks. Details of the model are included in Section A-6.6.3.

A-6.3.2 Package Regional Densities

Tables A-6.3-1 through A-6.3-3 summarize the calculated atom densities unique to the homogeneous and heterogeneous models, and those which are common to both.

Table A-6.3-1

Homogeneous Model Fuel Atom Densities

Mixture/ Density	Atom Density atoms/b-cm	Comments
FUEL		
U235	3.0547E-04	Smeared over 7x7 rod cell array
U238	7.3314E-03	Smeared over 7x7 rod cell array
O	3.3390E-02	Smeared over 7x7 rod cell array
H	3.6232E-02	Smeared over 7x7 rod cell array
Zr	4.8171E-03	Smeared over 7x7 rod cell array

Table A-6.3-2

Heterogeneous Model Fuel Atom Densities

Mixture/ Material	Atom Density atoms/b-cm	Comments
FUEL PELLET		
O	4.6551e-02	
U235	9.3102e-04	
U238	2.2345e-02	
CLADDING		
Nat. Zr	3.7349E-02	Smeared over fuel-clad gap

Table A-6.3-3

Regional Atom Densities - All Models

Mixture/ Nuclide	Atom Density (#/b-cm)	Comments
WATER		
H	6.6855e-02	4C water (maximum density)
O	3.3427e-02	4C water (maximum density)
H	6.6736e-02	20C water (nominal density)
O	3.3368e-02	20C water (nominal density)
H	6.4074e-02	100C water
O	3.2037e-02	100C water
H	5.0052e-02	75% fog
O	2.5026e-02	75% fog
H	3.3368e-02	50% fog
O	1.6684e-02	50% fog
H	1.6684e-02	25% fog
O	8.3421e-03	25% fog
H	3.3368e-03	5% fog
O	1.6684e-03	5% fog
SS304		
Fe	6.2127e-02	
Cr	1.7670e-02	
Ni	7.6201e-03	
DEPLETED URANIUM		
U235	1.0613e-04	
U238	4.7528e-02	
FUEL CHANNEL		
Nat. Zr	4.2910e-02	Unsmeared
NEUTROSORB POISON		
Fe	5.4808e-02	1.0 w/o 94% Enriched B-10
Cr	1.7076e-02	1.0 w/o 94% Enriched B-10
Ni	1.0747e-02	1.0 w/o 94% Enriched B-10
B-10	4.1467E-03	1.0 w/o 94% Enriched B-10
Mn	8.5061e-04	1.0 w/o 94% Enriched B-10

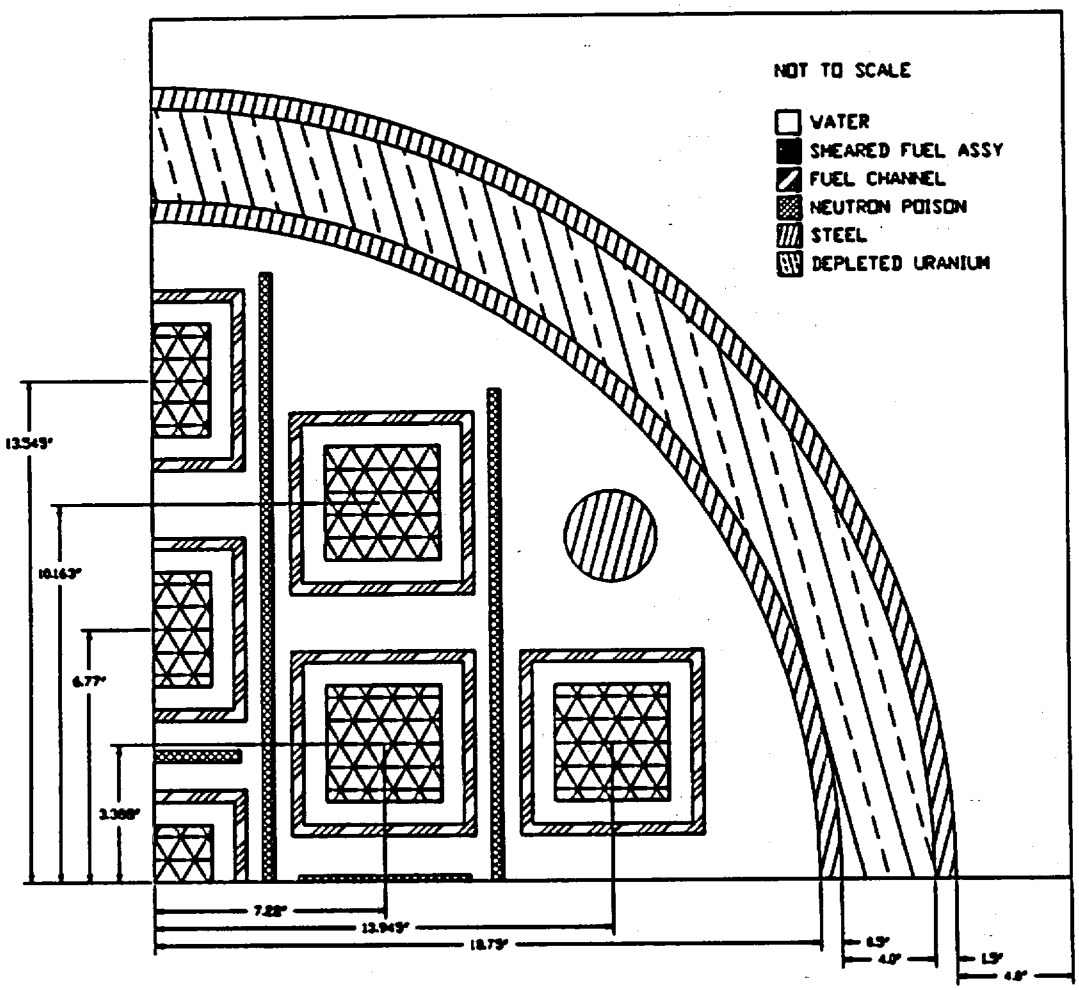


Figure A-6.3-1

Quarter Cask KENO Model, Materials

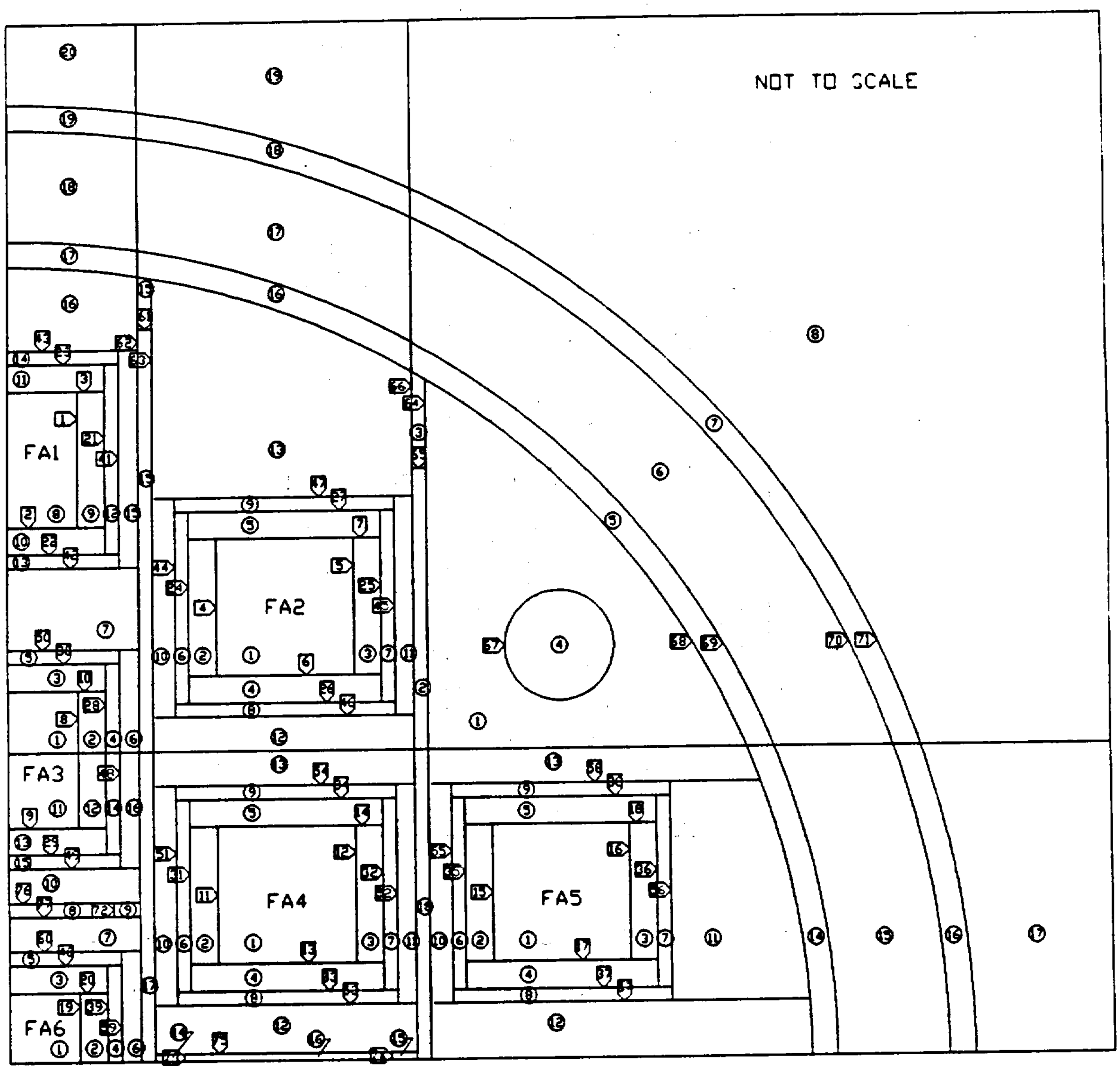


Figure A-6.3-2

Quarter Cask KENO Model, Sectors/Surfaces

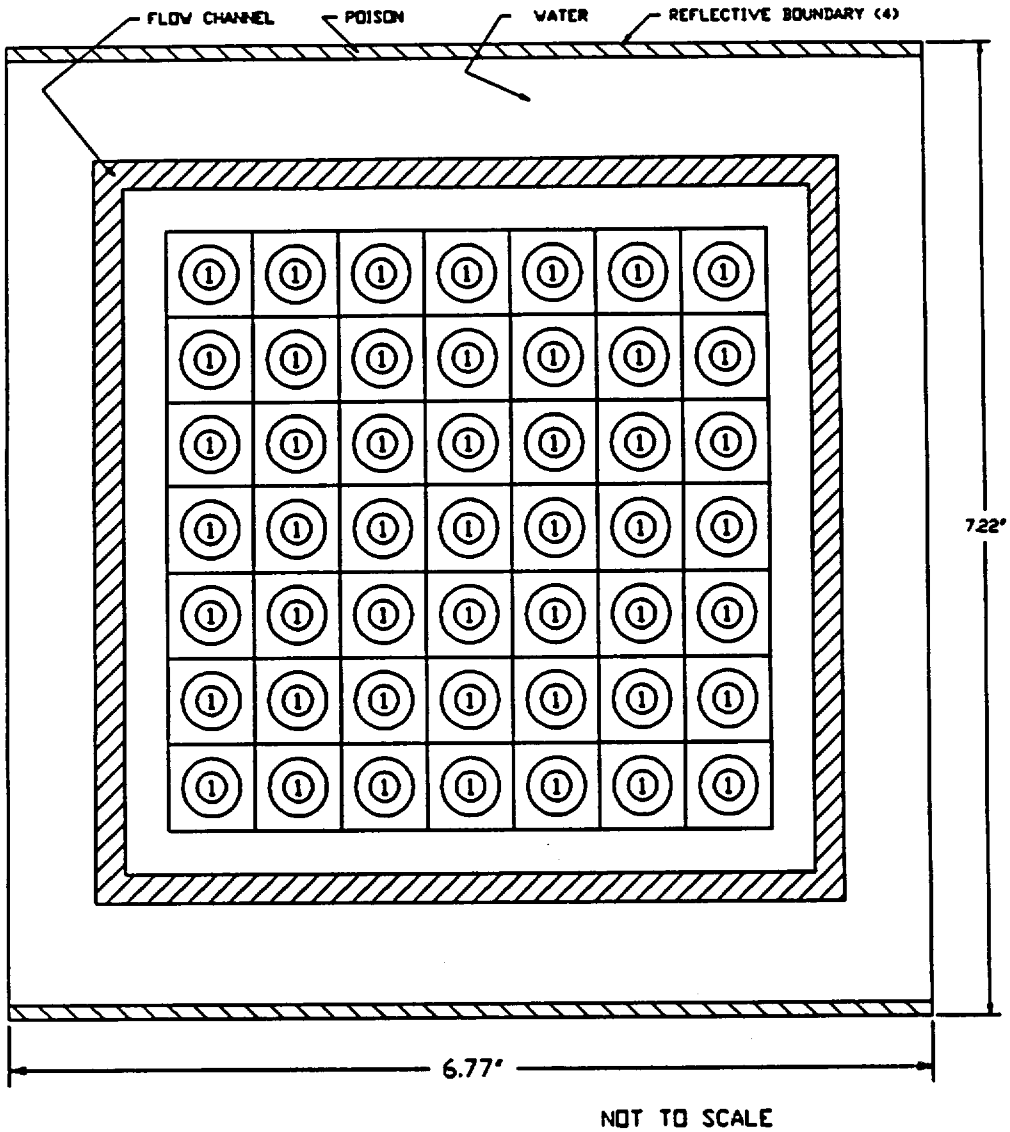


Figure A-6.3-3

Infinite Array KENO Model IA1

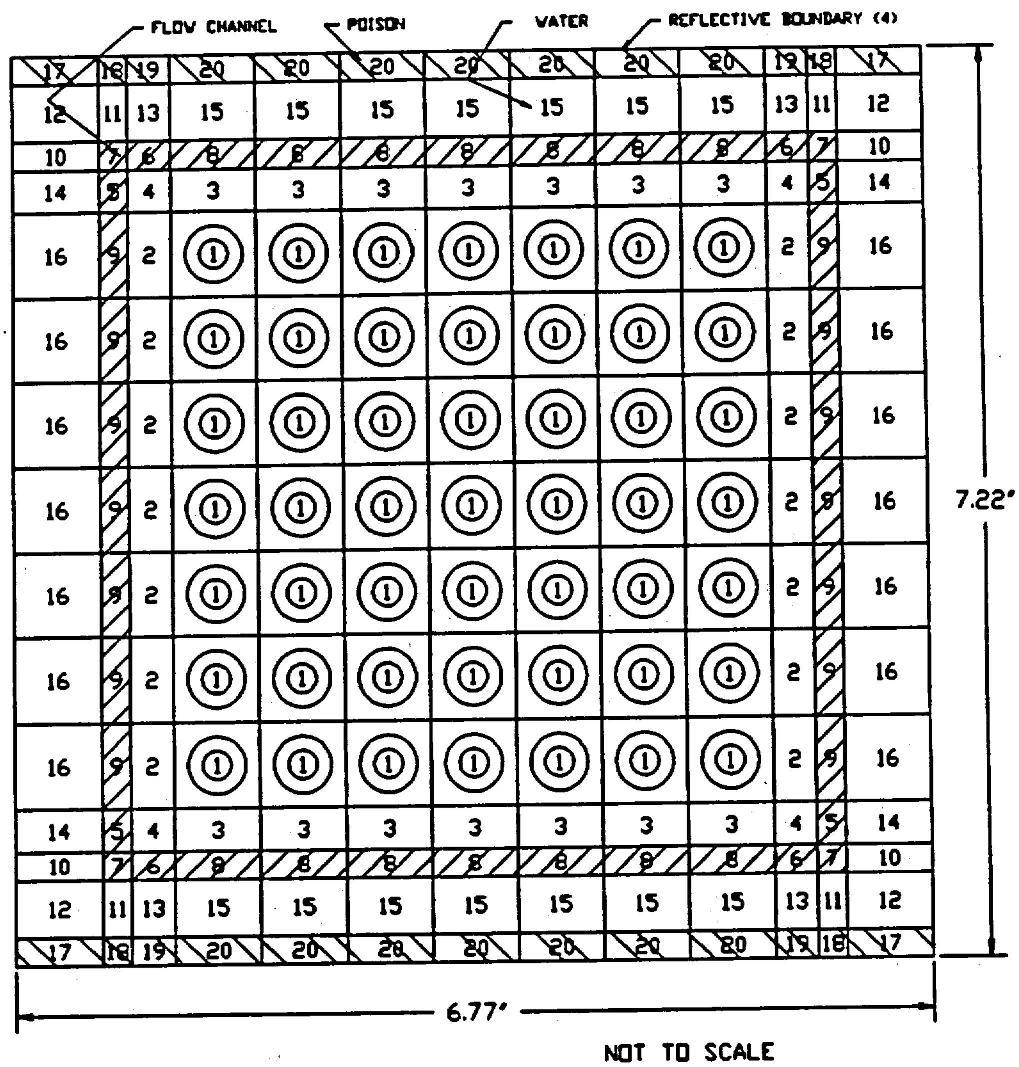


Figure A-6.3-4

Infinite Array KENO Model IA2

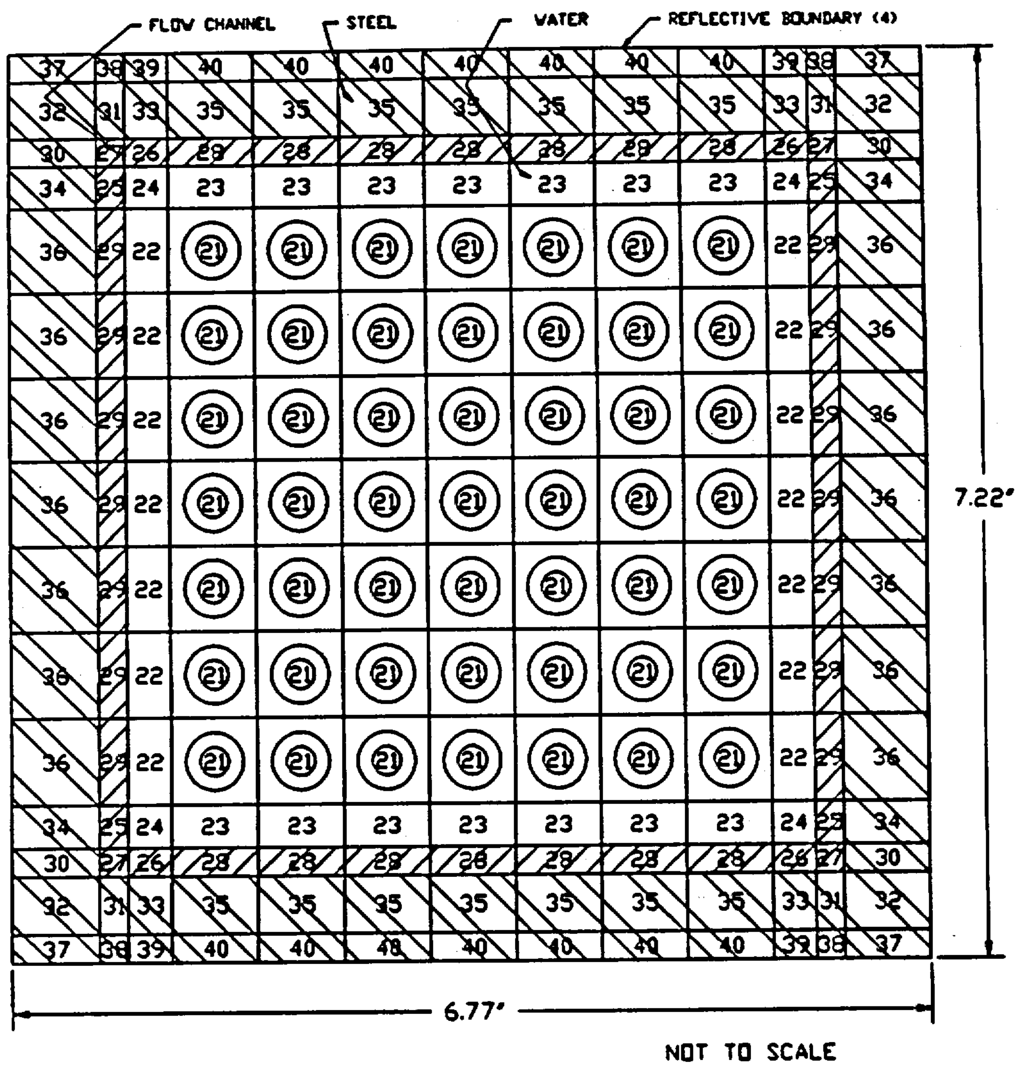


Figure A-6.3-5

Infinite Array KENO Model IA2 (Spacer Disks)

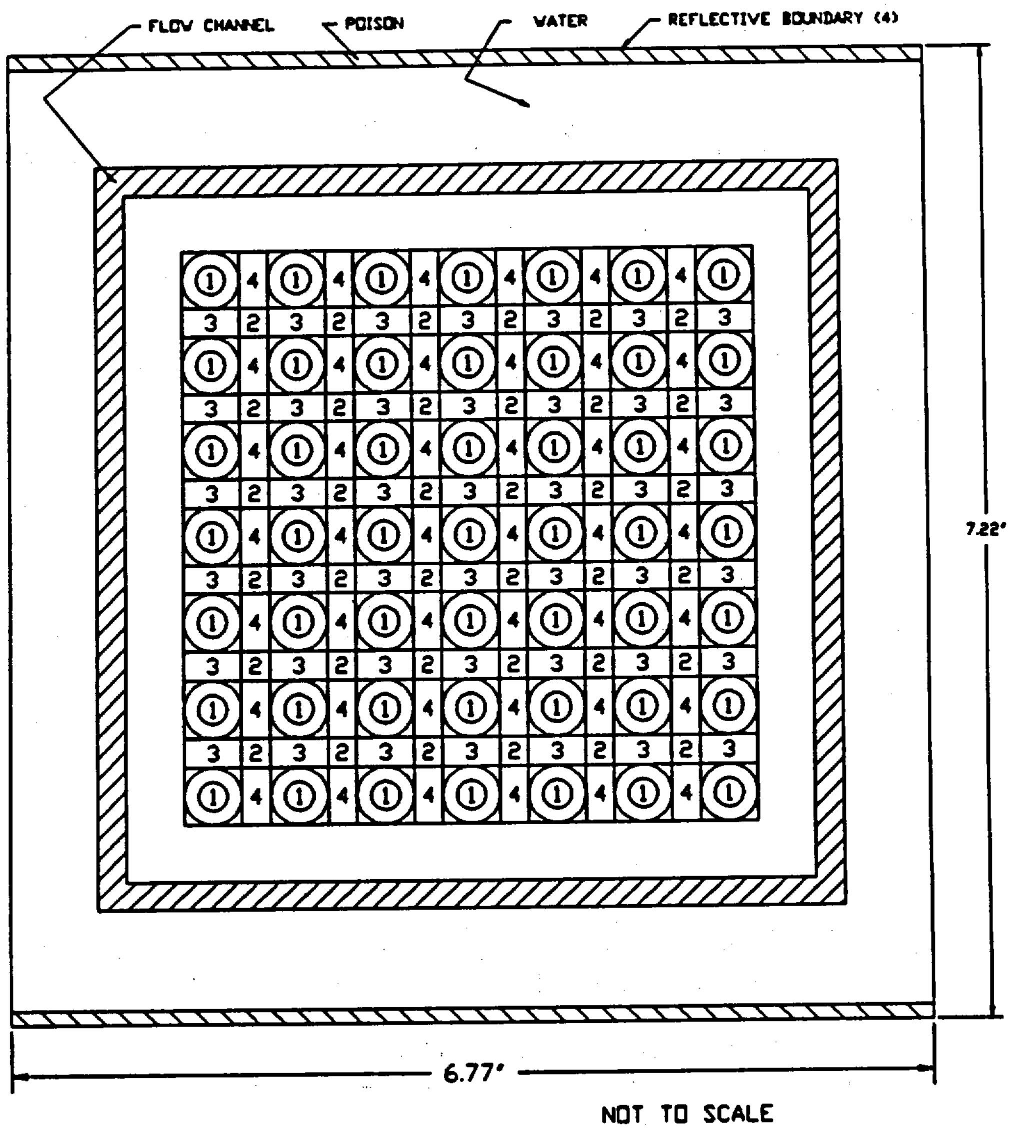


Figure A-6.3-6

Infinite Array KENO Model IA3

A-6.4 Criticality Calculation

A-6.4.1 Calculational Method

Criticality calculations were performed using KENO-IV [A-6.6.1-11] and a working cross section library. The working library was created from the XSDRN 123 group neutron cross section master library [A-6.6.1-11] using the computer codes NITAWL [A-6.6.1-13] and XSDRNPM [A-6.6.1-14].

NITAWL is used to perform resonance treatments on the U238 nuclide in the fuel pellets and in the depleted uranium used to fabricated the cask walls. The fuel resonance treatments are performed using a Dancoff Factor of 0.1675. Sauer's Approximation for cylindrical cells in a square lattice [A-6.6.1-15] is used for calculating the Dancoff factor. This method treats the rods as infinitely long cylindrical lumps and does not include cladding effects. Sauer's method is adequate for LWR rods since the cladding is neither thick nor a strong absorber.

XSDRNPM is used to model a single fuel rod cell including the fuel pellet, fuel rod cladding, and a water layer whose radius is chosen to preserve the fuel/moderator ratio. The purpose of the XSDRN run is to generate cell weighted (homogenized) cross sections which are subsequently used in KENO. The original 123 group energy structure is preserved during this process. The homogenization process is summarized in Figure A-6.4-1 and the input files are located in Section A-6.6.3.1.

The homogenization process is necessary since KENO-IV cannot efficiently model a large system, such as this multi-element shipping cask, using discrete fuel rods. Instead, fuel assemblies are modeled as homogeneous cuboids having the dimensions of their heterogeneously modeled equivalent. Each element is then surrounded by a thin layer of water, then a layer of zirconium (fuel channel) to represent a complete fuel assembly.

A-6.4.2 Fuel Loading Optimization

The IF-300 Channelled BWR Fuel Basket criticality analysis is performed using the most reactive fuel design of a list of candidate fuel designs (Table A-6.2-2). In order to assure that the requirements of 10CFR71, Sections 71.55 and 71.57, are satisfied, the licensing case KENO model is specified with 100% specular albedo conditions on all six sides. The result is a simulation of an infinite square array of

infinitely long casks. Further discussion regarding this model can be found in Section A-6.3.1.1.

A-6.4.3 Criticality Results

The nominal case is a KENO quarter-cask model with all assemblies assumed to be centered in their basket locations immersed in 20°C water moderator. The calculated reactivity for this case is:

$k_{eff} = 0.88990 \pm 0.00374\ (1\sigma)$.

The safety requirements of ANSI/ANS-8.17 [A-6.6.1-4] prescribe that all applicable biases and uncertainties must be investigated and statistically attached to this nominal case k_{eff}. The following sections briefly describe each case analyzed, and present the calculated results.

1. Summary of Biases and Uncertainties

   1. Method Biases

      A. Benchmark Bias: The benchmark bias represents the amount by which KENO-IV, in conjunction with the XSDRN 123 group master cross section library, deviates from the results of critical experiments at a 95% certainty with a 95% confidence (95/95 confidence). It is calculated to be 0.00840 ± .00976 (non-conservative direction, 2σ) for this application. Details regarding the calculation of the benchmark bias are provided in Section A-6.5.

      B. Modeling Biases: The modeling technique used in the analysis of the IF-300 Channelled BWR Fuel Basket design differs in some respects from the methodology used in the KENO benchmark analysis [A-6.6.1-16]. The bias introduced by each of these differences is estimated as described in (i) and (ii) below.

         (i) Homogenization Technique

         The nominal quarter cask model utilizes cell-weighted, or homogenized, cross sections for the fuel assemblies. Since the benchmark calculations [A-6.6.1-16] were performed using rod by rod

(heterogeneous) modeling, a computational bias may be introduced due to the cross section generation procedure.

Two infinite array KENO models were constructed to establish the homogenization bias. The infinite reactivity of a rod-by-rod (heterogeneous) system is calculated to be:

$k_\infty = 1.01886 \pm 0.00355\ (1\sigma)$

The same array configuration, using homogenized cross sections, is calculated to be:

$k_\infty = 1.03448 \pm 0.00405\ (1\sigma)$

(ii) Infinite Length/No Spacer Disk Assumption

In order to license the IF-300 Channelled BWR Fuel Basket as a Fissile Class I package, it must be shown that any number of packages would remain subcritical [A-6.6.1-1]. This is interpreted as being satisfied by modeling an infinite square array of infinitely long casks by using the albedo boundary condition feature of KENO.

The nominal case model is constructed with 100% specular albedo conditions in all directions. The resulting k_{eff} corresponds to a 2-D infinite array of casks containing infinitely long fuel assemblies. The axial reflecting regions in the fuel assembly end fittings and cask lids are not modelled.

The nominal case does not model the spacer disks, nor does it account for the fact that the poison in the basket does not pass through the thickness of the spacer disk.

In order to assess the impact of this methodology, two infinite array models are compared. Both

cases have specular albedo conditions specified on all sides. The reflector model includes plenum/endfitting and cask lid reflecting regions. The infinite length model includes only fuel rods.

The infinite reactivity of an infinitely long system with no spacer disks is calculated to be:

$k_\infty = 1.01886 \pm 0.00355\ (1\sigma)$

The reflected system with spacer disks and non-contiguous absorber sheets is calculated to be:

$k_\infty = 1.01014 \pm 0.00429\ (1\sigma)$

This result substantiates the assumption that the spacer disks have a negative effect on the system reactivity. For conservatism, no credit is taken for this bias.

2. Mechanical Uncertainties

ANSI/ANS-8.17-1984 [A-6.6.1-4] requires that mechanical uncertainties be considered in the criticality analysis and that those uncertainties should be statistically combined. The effects of variations in moderator temperature/density, fuel assembly location, fuel rod pitch, and neutron absorber manufacturing tolerance are evaluated as discussed in A through D below, and are considered as uncorrelated uncertainties [A-6.6.1-17] for this analysis.

A. Moderator Temperature/Density: A parametric study is performed to determine the behavior of k_∞ as the moderator temperature and density are varied. Two temperature variations are run assuming the moderator is liquid water. These, combined with the nominal case, provide three temperature/density data points. Four additional cases are run assuming the moderator is saturated steam at various densities. The various cases are summarized below.

Case	T(°C)	Density (g/cc)
4°C	4	1.000000
Nominal	20	0.998230
100°C	100	0.958400
75% Fog	100	0.748673
50% Fog	100	0.499115
25% Fog	100	0.249558
5% Fog	100	0.049912

The results of the moderator temperature/density study are shown in A-6.4-2. It is concluded that the system is most reactive at the 4°C condition (maximum water density). The reactivity falls monotonically with respect to moderator density which leads to the observation that the system is undermoderated with respect to overall moderator density.

The infinite reactivity of the system with 20°C water moderation is calculated to be:

$k_\infty = 1.01886 \pm 0.00355$ (1σ)

The reactivity of the system at maximum water density is calculated to be:

$k_\infty = 1.02249 \pm 0.00461$ (1σ)

B. Fuel Assembly Location: The nominal case quarter-cask model is run with all assemblies inward and with all assembles positioned outward in their storage locations. Dimensions of the IF-300 Channelled BWR Fuel Basket and the fuel channels are used as a basis for determining the amount of offset which could be assumed to occur. A stack of manufacturing tolerances is included in the offset calculation. The total effective fuel assembly offset is calculated to be 0.268" applied simultaneously in the X and Y model directions. It is determined that the system is most reactive when the assemblies are in the most closely packed configuration.

The reactivity of the system at nominal spacing is calculated to be:

$k_{eff} = 0.88990 \pm 0.00374$ (1σ)

The reactivity of the system at close-packed spacing is calculated to be:

$k_{eff} = 0.90752 \pm 0.00492\ (1\sigma)$

The reactivity of the system at far-packed spacing is calculated to be:

$k_{eff} = 0.88047 \pm 0.00502\ (1\sigma)$

It can be concluded from these results that the system is slightly overmoderated with respect to the assembly pitch. It is therefore true that the system reactivity would decrease from the nominal case for payloads less than 17 assemblies[2].

C. Fuel Rod Pitch: Since it is conceivable that the fuel rod pitch may be distorted in a drop event, it has been analyzed as a mechanical uncertainty. This distortion may only exist temporarily during the drop, or it may be a permanent deformation. It is noted that this assumption is nonmechanistic and that a fuel drop accident would most likely result in decreased fuel rod pitches only.

The model is run at four different rod pitches which, when combined with the baseline case, provide five data points. The rod pitches are calculated assuming that the minimum pitch is defined by near rod contact in a square array and by near contact with the fuel channel. For the purpose of this analysis, it is assumed that the rods remain in a square array and that the array remains centered in the flow channel. The fuel rod pitches evaluated are:

[2]Note that, as indicated by the rod pitch study and the moderator density study, the assemblies themselves are undermoderated such that no fuel with missing fuel rods should be loaded. Such fuel would be acceptable if dummy rods were inserted to retain the assembly's fuel/moderator ratio.

	(in)	(cm)
Min. rod pitch	0.5634	1.4310
Mid-min. rod pitch	0.6507	1.6528
Nom. rod pitch	0.7380	1.8745
Mid-max. rod pitch	0.7632	1.9385
Max. rod pitch	0.7884	2.0025

The sensitivity analysis results demonstrate that the nominal design pitch is nearly optimum since k_∞ drops by 0.28 at minimum pitch and rises by 0.07 at maximum pitch.

The results of the rod pitch study are shown in Figure A-6.4-3. It is concluded that the reference fuel assembly, in this poisoned configuration, is undermoderated with respect to inter-rod moderation.

Assuming that a drop accident would result in decreased rod pitch (due to spacer grid and/or rod deformation) the uncertainty in the cask k_{eff} due to the effects of rod pitch variation would therefore range from $\Delta k = 0.00$ to $\Delta k = -0.28$ (conservative direction). The uncertainty in cask k_{eff} shall be conservatively assumed zero.

D. Neutron Absorber Manufacturing Tolerances: The IF-300 Channelled BWR Fuel Basket design utilizes NeutroSorb Plus™ as a fixed neutron absorber which is required to achieve criticality control for the design basis fuel.

Sensitivity calculations are performed to determine the impact of absorber plate thickness variations on the system k_∞. All other parameters are considered to be worst case (maximum skin thickness, minimum boron content at minimum B-10 enrichment, minimum plate density). No parametric studies were run for boron content or isotopic enrichment since those parameters are specified as minimums and since they do not affect the overall fuel/moderator volume ratio.

It is determined that the minimum plate thickness of 0.240" presented the worst case for criticality. The infinite reactivity of the system with nominal thickness neutron absorber is calculated to be:

$k_\infty = 1.01886 \pm 0.00355 \ (1\sigma)$

The reactivity of the system with minimum thickness poison is calculated to be:

$k_\infty = 1.02851 \pm 0.00464 \ (1\sigma)$

2. Calculation of Maximum k_{eff}

The calculated maximum k_{eff} for the IF-300 Channelled BWR Fuel Basket includes all biases and uncertainties applicable to the calculational methodology and the design. The following relationship is used to combine the biases and uncertainties to arrive at the 95/95 maximum k_{eff}.

$$k_s = k_{nom} + B_{KENO} + B_{hom} + B_{disks} + \sqrt{U_{nom}^2 + U_\infty^2 + U_{keno}^2 + U_{hom}^2 + U_{disks}^2 + U_{mech}^2}$$

$$= 0.88990 + 0.00840 - 0.01562 + 0.00000 + \sqrt{0.00748^2 + 0.00710^2 + 0.00976^2 + 0.00810^2 + 0.00000^2 + 0.03574^2}$$

$$= 0.92198$$

Table A-6.4-1 provides a detailed breakdown of each of the terms in the above equation.

It is concluded that the IF-300 Channelled BWR Fuel Basket is critically safe under the conditions imposed by 10CFR71.

Table A-6.4-1

Summary of Criticality Biases and Uncertainties

Reference Cases	$k \pm 1\sigma$		95/95 Uncertainty keff $\pm 2\sigma$
Quarter Cask Reference Case	0.88990 ± 0.00374		0.88990 ± 0.00748 (k_{nom}) (U_{nom})
Infinite Array Reference Case	1.01886 ± 0.00355		1.01886 ± 0.00710 (k_{inf}) (U_{inf})
Calculational Bias	**Reference Case $k \pm 1\sigma$**	**Sensitivity Case $k \pm 1\sigma$**	**95/95 Uncertainty delta k $\pm 2\sigma$**
KENO/XSDRN123 Bias			0.00840 ± 0.00976 (B_{KENO}) (U_{KENO})
Homogenization Technique	1.01886 ± 0.00355	1.03448 ± 0.00405	-0.01562 ± 0.00810 (B_{hom}) (U_{hom})
No Disks, Inf. L Assumption	1.01886 ± 0.00355	1.01014 ± 0.00429	0.00000 ± 0.00000 (B_{disks}) (U_{disks})
Mechanical Uncertainty	**Reference Case $k \pm 1\sigma$**	**Sensitivity Case $k \pm 1\sigma$**	**95/95 Uncertainty delta k + 2σ**
Moderator Temp/Dens	1.01886 ± 0.00355	1.02249 ± 0.00461	0.01285
Poison Thk. Tolerance	1.01886 ± 0.00355	1.02851 ± 0.00464	0.01893
Fuel Assembly Position	0.88990 ± 0.00374	0.90752 ± 0.00492	0.02746
Fuel Rod Pitch Variation			0.00000
TOTAL MECHANICAL UNCERTAINTY ------>			0.03574 (U_{mech})
k_s ------>			0.92198

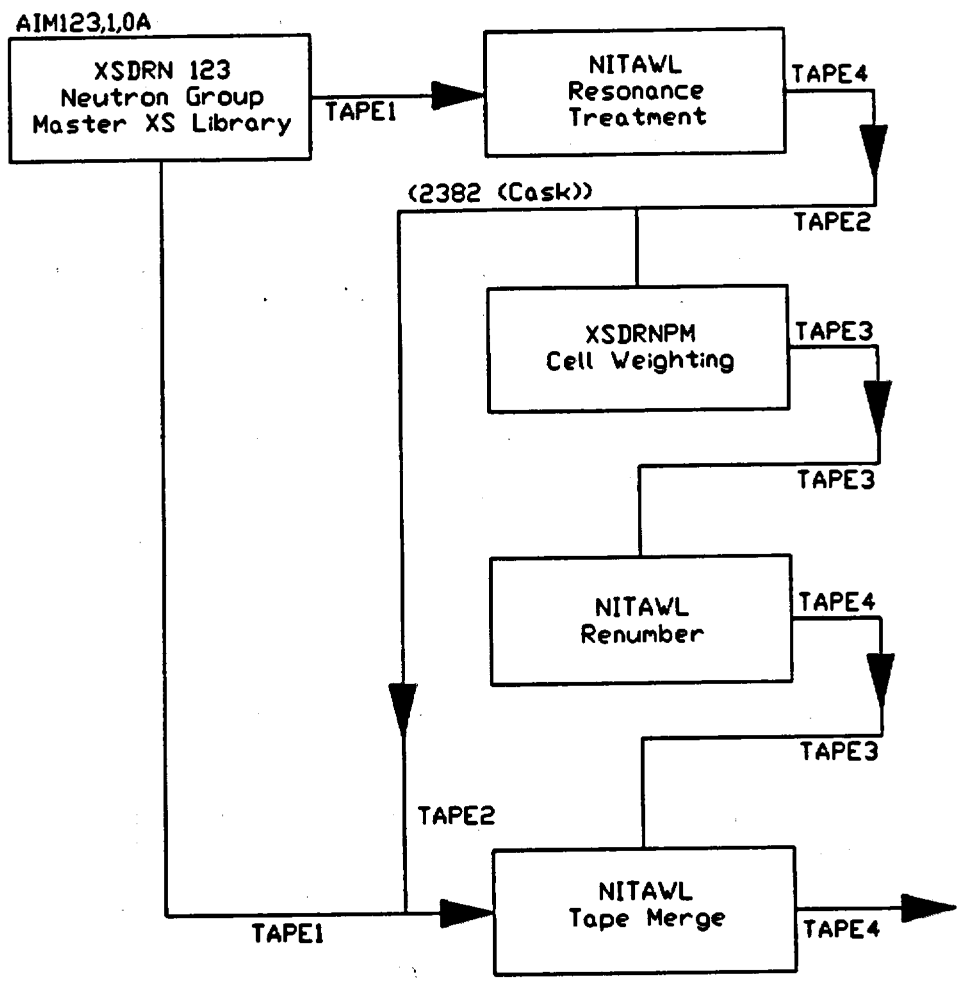


Figure A-6.4-1

Fuel Cross Section Homogenization Flowchart

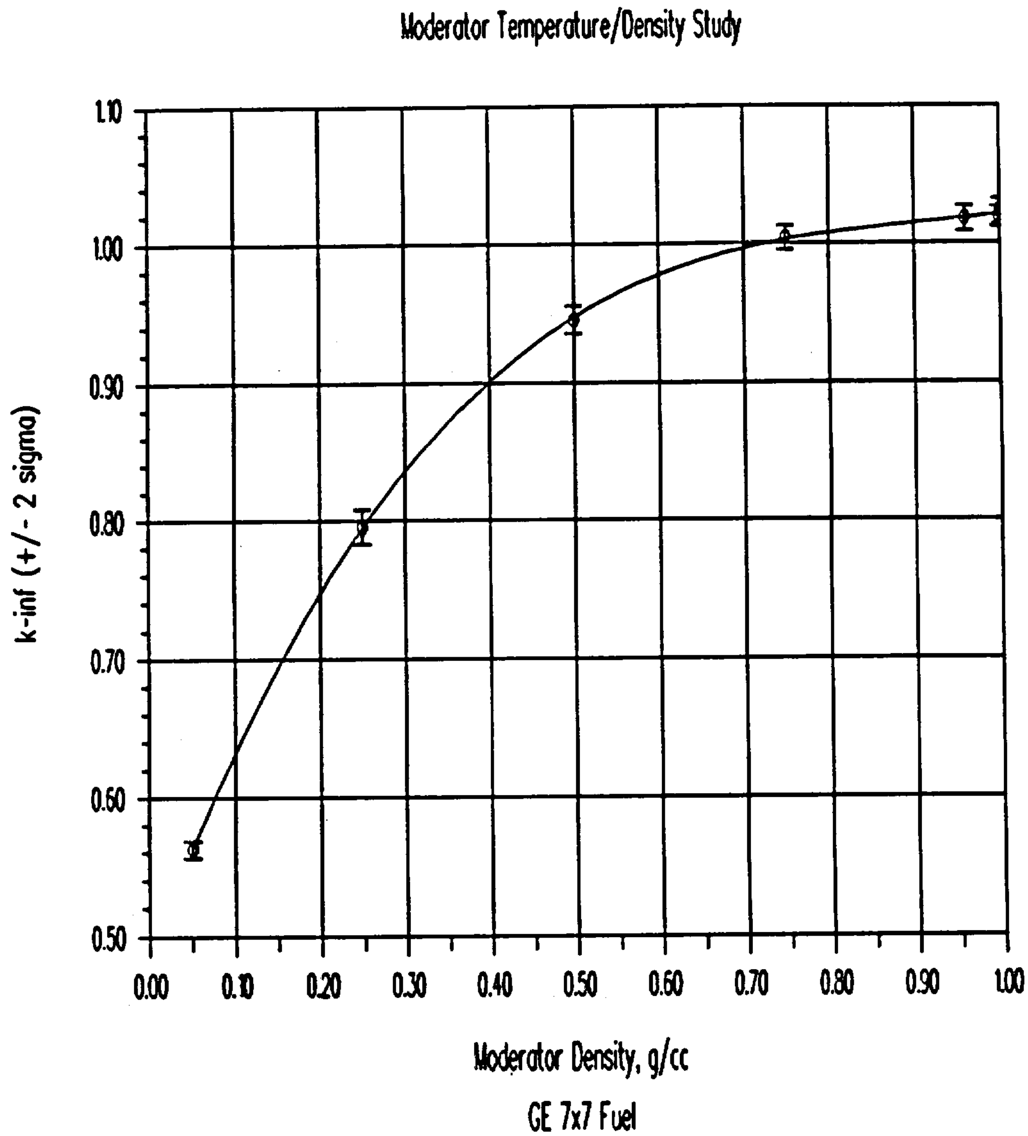


Figure A-6.4-2

Moderator Temperature/Density Study Results

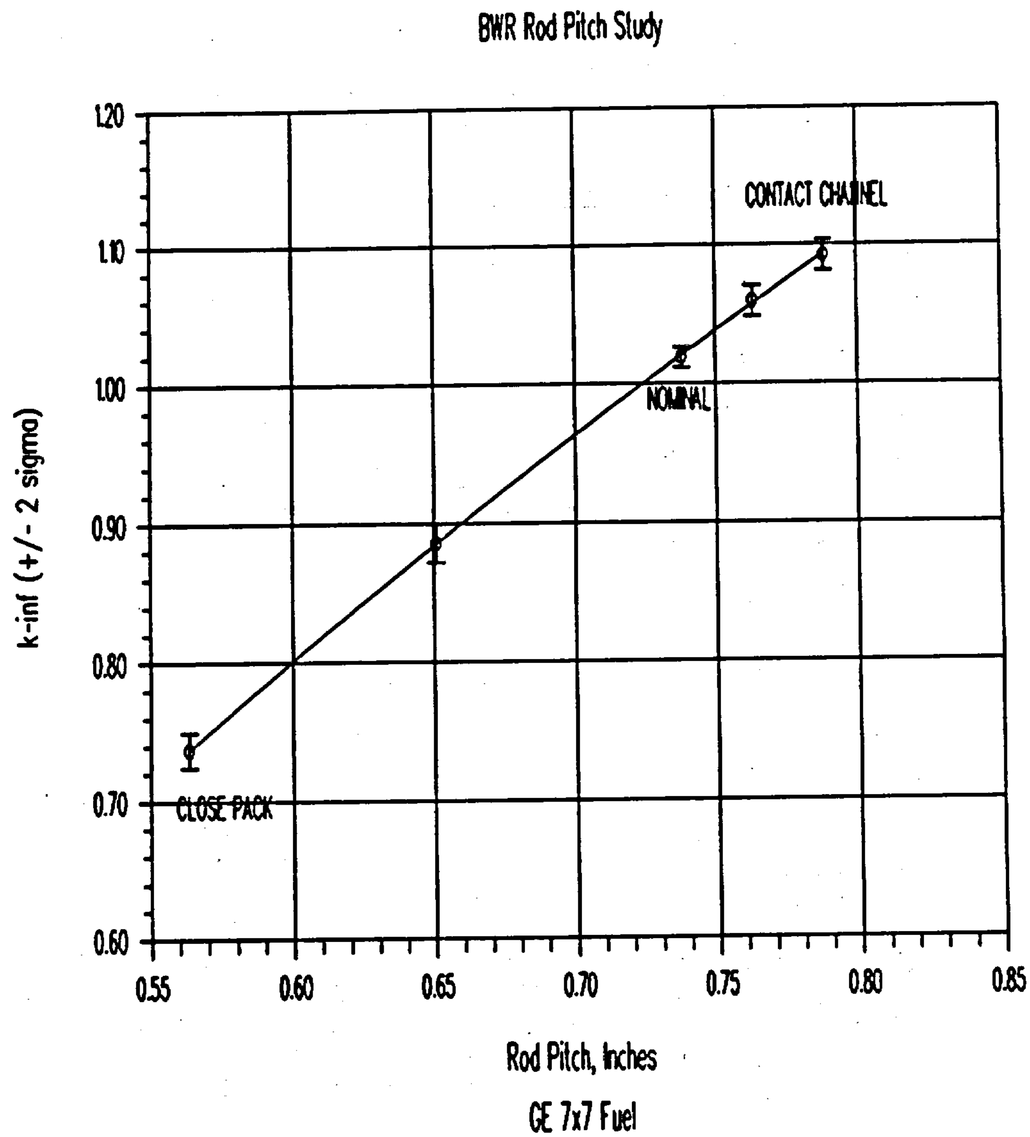


Figure A-6.4-3

Rod Pitch Study Results

A-6.5 Critical Benchmark Experiments

A review of published critical benchmark experiments indicated that the Babcock & Wilcox experiments [A-6.6.1-16] are applicable to the IF-300 Channelled BWR Fuel Basket geometry. This reference describes a series of 21 critical experiments using simulated LWR fuel and presents the results of KENO-IV calculations modeling these configurations. The critical benchmark calculations were performed using the same computer codes and cross section library as are used in the Channelled BWR Fuel Basket criticality analyses.

A-6.5.1 Benchmark Experiments and Applicability

The critical experiment arrangement consisted of a 3x3 array of fuel assemblies surrounded by light water in a tank constructed of steel and aluminum. The fuel was constructed of aluminum clad low-enriched UO_2 (2.459 w/o U-235) pellets in a 14x14 array. The core height was approximately five feet. Twenty one configurations were constructed to simulate a variety of close packed storage arrangements with differing fuel assembly spacing and neutron absorber material. The reactivity control elements included stainless steel plates, B_4C rods, and borated aluminum plates. Table A-6.5-1 shows the results of the criticality benchmark experiments.

A-6.5.2 Details of Benchmark Calculations

The KENO-IV code and XSDRN 123 group master cross section library [A-6.6.1-11] were used to model the critical configurations. The modeling technique incorporated a rod-by-rod representation of the fuel assemblies with explicit models of the material interspersed between assemblies. The cross sections for these cases were prepared by NITAWL [A-6.6.1-13]. All pertinent data for each critical configuration are documented in the B&W report [A-6.6.1-16] to permit use of these data for validating calculational methods in accordance with ANSI N16.9-1976 [A-6.6.1-6]. Table A-6.5-1 contains the results of the KENO calculations.

A-6.5.3 Results of Benchmark Calculations

The benchmark results indicate a mean calculational bias of $\Delta k = 0.0033 \pm 0.00487$ (1σ, non-conservative direction) for the gross average of all cases analyzed. This value is not justified for use as a benchmark bias, however, since a statistical review reveals that the data is not a single population. There is no sound correlation between the KENO bias and the type of material placed between the assemblies; nor is there a pronounced dependence on the boron content of the

absorbers. The only obvious bias correlation is with the inter-assembly spacing.

By grouping the results according to the inter-assembly spacing, it is possible to perform a linear regression on the average bias for each spacing. The results are provided in Table A-6.5-2. The bias from Core I at the 0.0 inch spacing has been excluded from the 0.0 inch population average since that core was a cylindrical geometry and is not applicable to the IF-300 basket. Figure A-6.5-1 shows the relationship between KENO bias and inter-assembly spacing.

Since the basket geometry has multiple inter-assembly spacings, the weighted average of the individual inter-assembly spacings must be used for establishing a benchmark bias. Substituting the average inter-assembly spacing of 1.731" into the equation derived by the regression fit, the KENO bias may be calculated as follows:

$$B_{KENO} = 0.00693 - S[inches] \times 0.0088936$$
$$= 0.00693 - 1.731 \times 0.00936$$
$$= 0.0084$$

The uncertainty in the KENO bias is given by the following equation where $U_{regression}$ is the standard error of the regression fit and $U_{benchmarks}$ is the mean uncertainty of all the benchmark biases.

$$U_{KENO} = 2\cdot\sqrt{U^2_{regression} + U^2_{benchmarks}}$$
$$= 2\cdot\sqrt{0.00032^2 + 0.00487^2}$$
$$= 0.00976 \quad (2\sigma)$$

Table A-6.5-1

Critical Benchmark Results

Spacing	Core/Material	Calculated keff	Measured keff
0.000	I/H2O	0.998 ± 0.006	1.0002 ± 0.0005
0.000	II/H2O	1.007 ± 0.004	1.0001 ± 0.0005
0.644	III/H2O	0.999 ± 0.004	1.0000 ± 0.0006
0.644	IV/84 B4C Pins	1.004 ± 0.007	0.9999 ± 0.0006
1.288	V/64 B4C Pins	1.005 ± 0.005	1.0000 ± 0.0007
1.288	VI/64 B4C Pins	0.998 ± 0.004	1.0097 ± 0.0012
1.932	VII/34 B4C Pins	0.994 ± 0.005	0.9998 ± 0.0009
1.932	VIII/34 B4C Pins	1.003 ± 0.005	1.0083 ± 0.0012
2.576	IX/H2O	0.987 ± 0.005	1.0030 ± 0.0009
1.932	X/H2O	0.988 ± 0.004	1.0001 ± 0.0009
0.644	XI/SS Plate	1.015 ± 0.004	1.0000 ± 0.0006
1.288	XII/SS Plate	0.991 ± 0.005	1.0000 ± 0.0007
0.644	XIII/1.6/Al Plate*	1.008 ± 0.005	1.0000 ± 0.0010
0.644	XIV/1.3B/Al Plate	1.003 ± 0.004	1.0001 ± 0.0010
0.644	XV/0.41B/Al Plate	0.995 ± 0.005	0.9998 ± 0.0016
1.288	XVI/0.41B/Al Plate	0.990 ± 0.005	1.0001 ± 0.0019
0.644	XVII/0.24B/Al Plate	0.993 ± 0.005	1.0000 ± 0.0010
1.288	XVIII/0.24B/Al Pl	1.005 ± 0.005	1.0002 ± 0.0011
0.644	XIX/0.1B/Al Plate	0.991 ± 0.004	1.0002 ± 0.0010
1.288	XX/0.1B/Al Plate	0.997 ± 0.005	1.0003 ± 0.0011
1.932	XXI/0.1B/Al Plate	0.981 ± 0.004	0.9997 ± 0.0015
Mean		0.99771 0.00476	1.00102 0.00098
Standard Deviation		8.1e-03 7.5e-04	2.7e-03 3.6e-04
Variance		6.6e-05 5.6e-07	7.2e-06 1.3e-07

Table A-6.5-2

KENO-IV Biases Grouped by Assembly Spacing

Spacing (inch)	Core/Material	KENO-Measured
0.000	I/H2O	-0.0022 +/- 0.0060
0.000	II/H2O	0.0069 +/- 0.0040
	0.000" average-->	0.0069 +/- 0.0040
0.644	III/H2O	-0.0010 +/- 0.0040
0.644	IV/84 B4C Pins	0.0041 +/- 0.0070
0.644	XI/SS Plate	0.0150 +/- 0.0040
0.644	XIII/1.6/Al Plate*	0.0080 +/- 0.0051
0.644	XIV/1.3B/Al Plate	0.0029 +/- 0.0041
0.644	XIX/0.1B/Al Plate	-0.0092 +/- 0.0041
0.644	XV/0.41B/Al Plate	-0.0048 +/- 0.0052
0.644	XVII/0.24B/Al Plate	-0.0070 +/- 0.0051
	0.644" average-->	0.0010 +/- 0.0049
1.288	V/64 B4C Pins	0.0050 +/- 0.0050
1.288	VI/64 B4C Pins	-0.0117 +/- 0.0042
1.288	XII/SS Plate	-0.0090 +/- 0.0050
1.288	XVI/0.41B/Al Plate	-0.0101 +/- 0.0053
1.288	XVIII/0.24B/Al Plate	0.0048 +/- 0.0051
1.288	XX/0.1B/Al Plate	-0.0033 +/- 0.0051
	1.288" average-->	-0.0041 +/- 0.0050
1.932	VII/34 B4C Pins	-0.0058 +/- 0.0051
1.932	VIII/34 B4C Pins	-0.0053 +/- 0.0051
1.932	X/H2O	-0.0121 +/- 0.0041
1.932	XXI/0.1B/Al Plate	-0.0187 +/- 0.0043
	1.932" average-->	-0.0105 +/- 0.0046
2.576	IX/H2O	-0.0160 +/- 0.0051
	2.576" average-->	-0.0160 +/- 0.0051

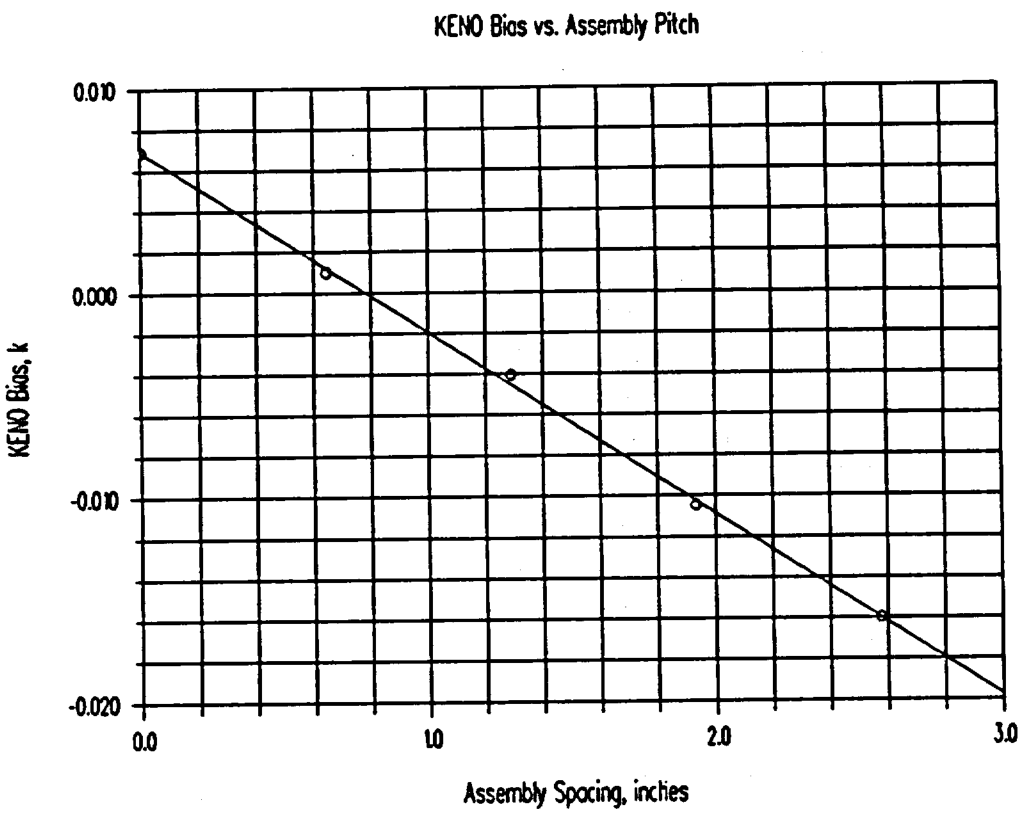


Figure A-6.5-1

KENO Bias Regression

A-6.6 <u>Appendix</u>

A-6.6.1 <u>References</u>

[1] "Packaging and Transportation of Radioactive Material," Title 10, Code of Federal Regulations, Part 71 (10CFR71), USNRC, 5/13/88.

[2] American Society for Testing and Materials, "Standard Specification for Borated Stainless Steel Plate, Sheet, and Strip for Nuclear Application," A887-88, <u>Annual Book of ASTM Standards</u>, Vol. 01.03, 1989.

[3] ANSI/ANS-8.1-1983, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors."

[4] ANSI/ANS-8.17-1984, "Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors."

[5] USNRC Regulatory Guide 3.41, Validation of Calculational Methods for Nuclear Criticality Safety," Revision 1, May, 1977.

[6] ANSI N16.9-1975, "Validation of Calculational Methods for Nuclear Criticality Safety."

[7] USNRC Regulatory Guide 1.13, "Spent Fuel Storage Facility Design Basis," Proposed Revision 2, December 1981 (for guidance only).

[8] "Certificate of Compliance for Radioactive Materials Packages," Model No. IF-300, Certificate No. 9001, Revision 23, Package Identification No. USA/9001/B( )F, Dated May 1990.

[9] Moore, R.S., Notz, K.J., "Physical Characteristics of GE BWR Fuel Assemblies," Oak Ridge National Laboratory, June, 1989, ORNL/TM-10902.

[10] "Domestic Light Water Reactor Fuel Design Evolution, Volume III," Nuclear Assurance Corporation, September, 1981, DOE/ET/47912-3.

[11] "KENO-IV: An Improved Monte Carlo Criticality Program," Oak Ridge National Laboratory, ORNL 4938, maintained by Babcock & Wilcox as BWNP-20373-4(4/87) for use on Power Computing's Cyber 990 system.

[12] Bierman, S.R., et al., "Criticality Experiments with Subcritical Clusters of 2.35 Wt% and 4.31 Wt% ^{235}U Enriched UO_2 Rods in Water With Steel Reflecting Walls," Battelle Pacific Northwest Laboratories, NUREG/CR-1784, April, 1981.

[13] "NITAWL: Nordheim Integral Treatment and Working Library Production," Babcock & Wilcox Co., NPGD-TM-505, Rev. 8 (12/88) for use on Power Computing's Cyber 990 system.

[14] "XSDRNPM: A One-Dimensional Discrete-Ordinates Computer Code - B&W Version," Babcock & Wilcox Co., NPG-TM-13, (4/85) for use on Power Computing's Cyber 990 system.

[15] "SCALE-3: A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation," Oak Ridge National Laboratory, NUREG/CR-0200 (ORNL/NUREG/CSD-2) Vols. I, II, and III, December, 1984.

[16] M.N. Baldwin, et al., "Critical Experiments Supporting Close Proximity Water Storage of Power Reactor Fuel," BAW-1484-7, Babcock & Wilcox Company, Lynchburg, Virginia, July, 1979.

[17] Taylor, J.R., "An Introduction to Error Analysis," Oxford University Press, 1982.

A-6.6.2 <u>Reference Calculations</u>

[A] PNFSI Calculation Package, "IF-300 BWR Shipping Cask Criticality Analysis- Physical Properties Calculations," Revision 1, PNFSI File No. 420-11.0200.

[B] PNFSI Calculation Package, "IF-300 BWR Shipping Cask Criticality Analysis- Heterogeneous Cross Section Preparation," Revision 1, PNFSI File No. 420-11.0201.

[C] PNFSI Calculation Package, "IF-300 BWR Shipping Cask Criticality Analysis- Determination of Most Reactive Fuel Assembly," Revision 0, PNFSI File No. 420-11.0203.

[D] PNFSI Calculation Package, "IF-300 BWR Shipping Cask Criticality Analysis- Heterogeneous KENO Models," Revision 0, PNFSI File No. 420-11.0204.

[E] PNFSI Calculation Package, "IF-300 BWR Shipping Cask Criticality Analysis- Homogeneous Cross Section Preparation," Revision 0, PNFSI File No. 420-11.0205.

[F] PNFSI Calculation Package, "IF-300 BWR Shipping Cask Criticality Analysis- Homogeneous KENO Models," Revision 0, PNFSI File No. 420-11.0206.

[G] PNFSI Calculation Package, "IF-300 BWR Shipping Cask Criticality Analysis- Calculation of Maximum k_{eff}," Revision 0, PNFSI File No. 420-11.0207.

A-6.6.3 Input/Output Listings

1. Computer Inputs

Summary of Computer Inputs:

*See Section A-6.6.3.2 for computer output.